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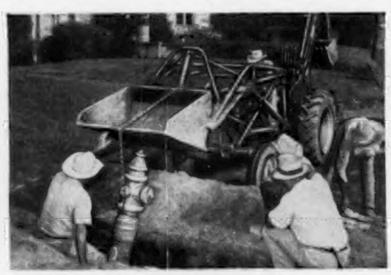

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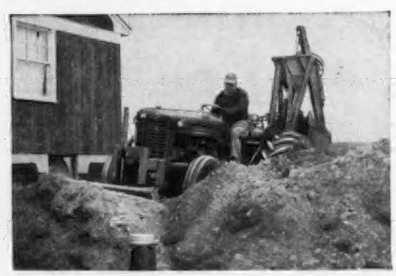

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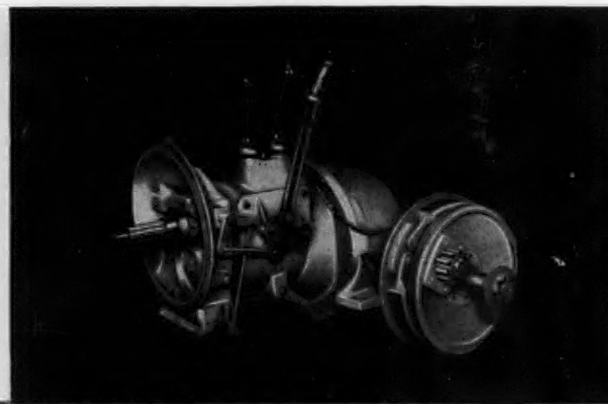

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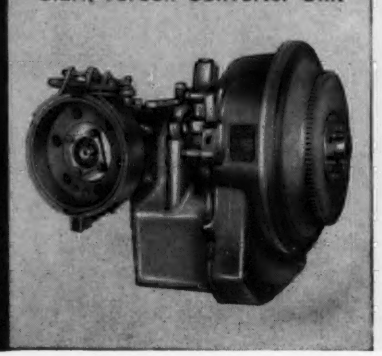

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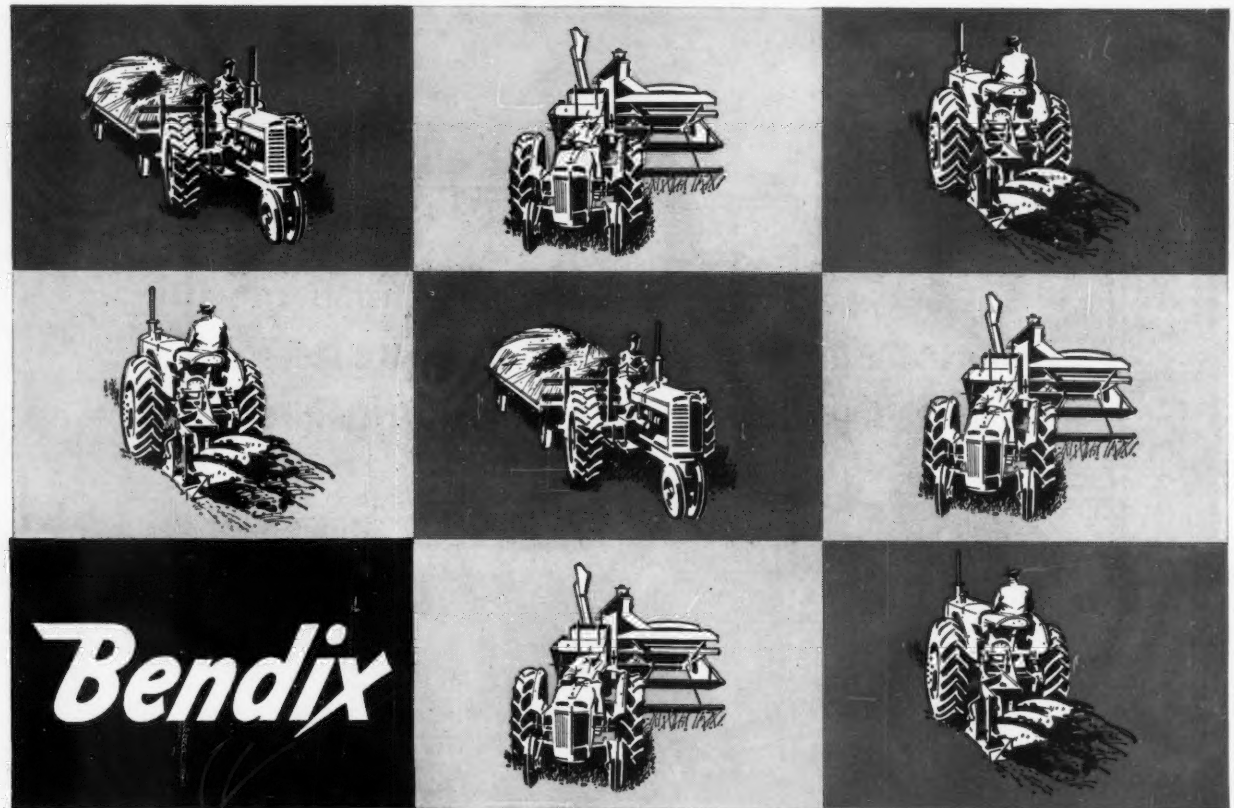

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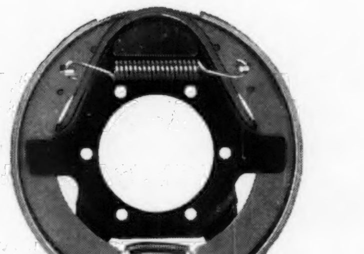

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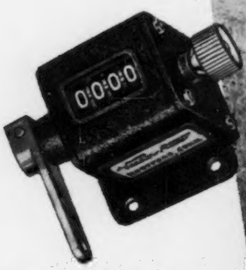

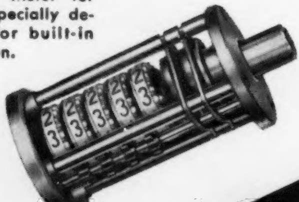


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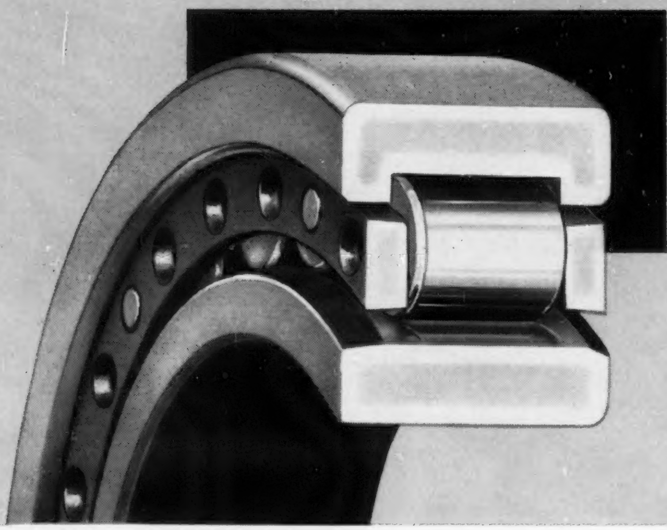

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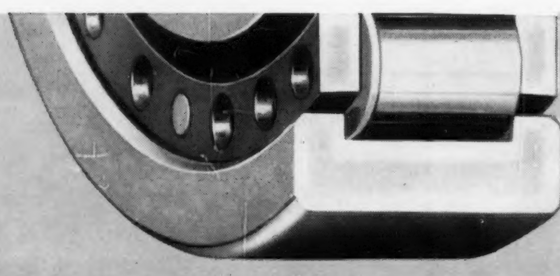

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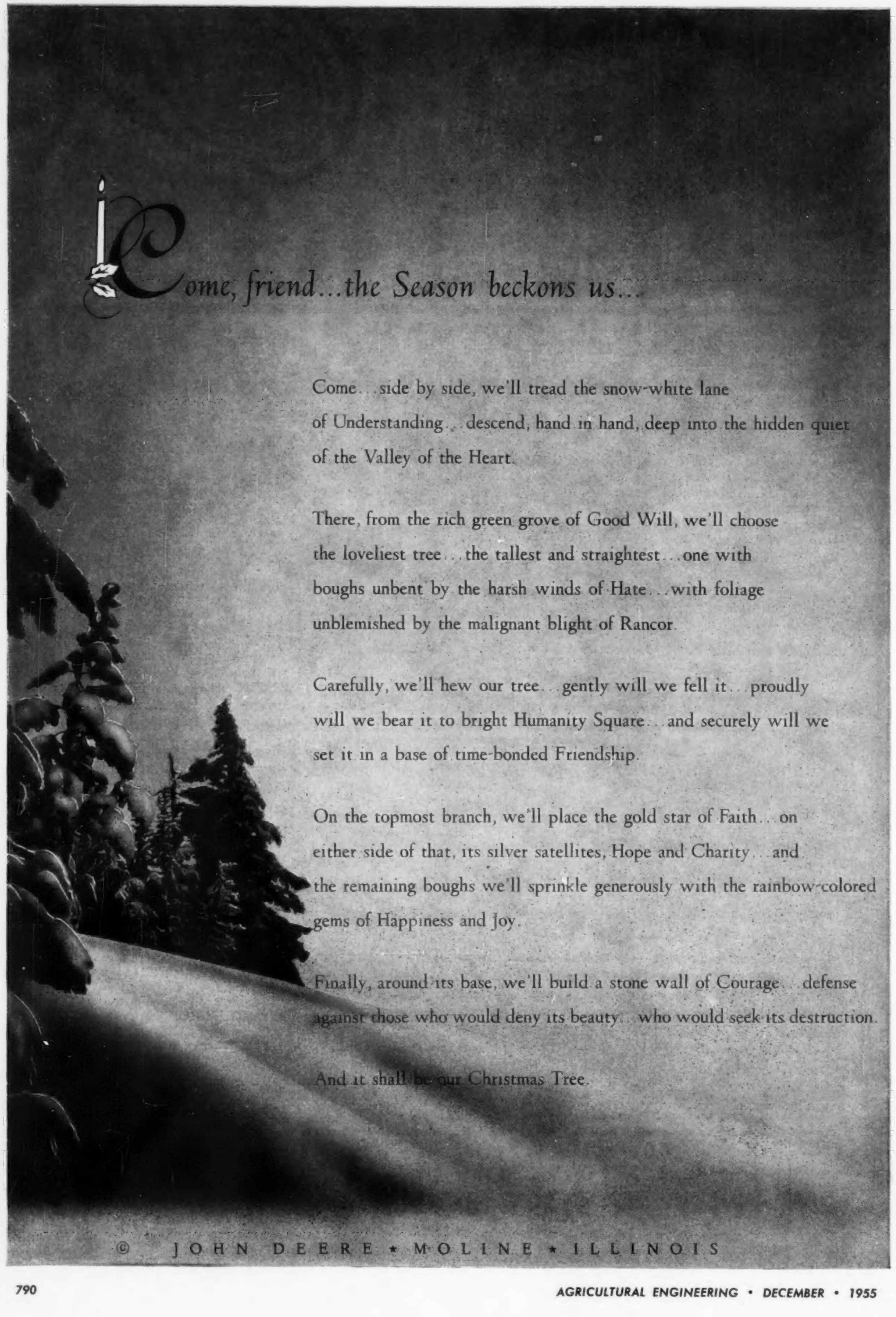
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Come...side by side, we'll tread the snow-white lane of Understanding...descend, hand in hand, deep into the hidden quiet of the Valley of the Heart.
There, from the rich green grove of Good Will, we'll choose the loveliest tree...the tallest and straightest...one with boughs unbent by the harsh winds of Hate...with foliage unblemished by the malignant blight of Rancor.
Carefully, we'll hew our tree...gently will we fell it...proudly will we bear it to bright Humanity Square...and securely will we set it in a base of time-bonded Friendship.
On the topmost branch, we'll place the gold star of Faith...on either side of that, its silver satellites, Hope and Charity...and the remaining boughs we'll sprinkle generously with the rainbow-colored gems of Happiness and Joy.
Finally, around its base, we'll build a stone wall of Courage...defense against those who would deny its beauty...who would seek its destruction.
And it shall be our Christmas Tree.
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AGRICULTURAL ENGINEERING

VOL. 36 DECEMBER, 1955 No. 12

Harvesting Corn by Combine

More Efficient Corn Harvesting

L. W. Hurlbut
Member ASAE

A summary of results of (1) laboratory and field tests by state agricultural experiment stations and (2) engineering development work by three farm equipment manufacturers, in adapting the grain combine to the harvesting of corn

THE need for more efficient corn-harvesting methods has been shown in reports of tests made during the past 25 years (5, 6, 7, 8, 9, 10, 11)* to determine the harvesting efficiency of mechanical corn pickers. In many reports there is evidence that the economics of corn production is as much dependent on efficient harvests and the means for preserving the quality of the grain, as it is on high-yielding hybrids.

In considering the corn harvest from the standpoint of farmers who diversify the production of grain crops, it appears that the ideal machine for harvesting corn should *(a)* be versatile enough to harvest the small grain crops as well as the corn crop, *(b)* pick up fallen ears, and *(c)* collect all shelled corn.

These ideal features suggest that the small-grain combine might be modified so that it would also serve effectively for harvesting corn. Some of the earliest attempts to use the combine for harvesting corn were made in Australia in 1924 (2), in Iowa in 1928 (3) and in Kansas and Nebraska in 1930 (4). These early reports all indicate that the threshing and cleaning units functioned quite satisfactorily.

The early investigators generally concluded that the future development and the universal use of the combine for harvesting corn would be dependent upon the development of new ways and means for drying shelled corn subsequent to harvest. Rapid advancements now being made in the development of grain-drying methods and equipment suitable for use on the farm indicate that grain drying will become a common farm practice (12) and that harvesting corn by combine can be done to the satisfaction of the farmer.

With an ideal corn-harvesting machine in mind, work was started in 1950 at the Nebraska Agricultural Experiment Station on an experimental ear-corn harvesting attachment which would mount on the platform of a combine(Fig. 1). This device is designed so that the incoming cornstalks pass between two inclined gathering points equipped with standard lug-type gathering chains. The stalks are then cut by the combine sickle, and as they move rearward of the sickle they encounter notches in a forked arm which steady the severed end of the stalks until a short auger forces them between the snapping rolls. The snapping rolls are located rearward of the cutter bar and directly above the platform canvas. One roll is set above the other, the lower roll being enough longer than the upper roll to provide for a short section of auger which forces the stalks between the snapping rolls. The snapping rolls are set at an angle (about 30 deg) to the row so as to cause the stalks to travel away from the row while at the same time they travel forward between the snapping rolls. The stripped stalks are ejected forward over the cutter bar onto the ground. The ears, and most of the corn that is shelled by the snapping rolls, will fall onto the platform. The elevator canvas is equipped with enlarged slats so that it can convey the ears and the shelled corn to the threshing cylinder.

Condensed symposium of six papers presented at the annual meeting of the American Society of Agricultural Engineers at Urbana, Ill., June, 1955, on a program arranged by the Power and Machinery Division. Approved for publication by the Director as paper No. 734, Journal Series, Nebraska Agricultural Experiment Station.

The author—L. W. HURLBUT—is chairman, agricultural engineering department, University of Nebraska.

*Numbers in parentheses refer to the appended references.

Fig. 1 An experimental corn-harvesting attachment for a combine platform. Cut stalks enter a pair of snapping rolls, and as they move laterally, they are ejected forward onto the ground

A production self-propelled combine was used during the harvest season of 1954 for harvesting the corn crop as well as some small grains. A 2-row corn-snapping attachment and a standard combine platform were interchangeable. This combine was used to harvest a field of corn well populated with corn borers and weeds. The total yield from the test areas in this field ranged from 85 to 100 bu per acre. The data from harvesting tests indicate that the threshing and separating units wasted only about 2 percent of the total corn yield, whereas the preharvest losses plus the snapper and gathering losses amounted to from 13 to 30 percent of the total yield as the season progressed.

The combining of corn generally can commence 7 to 10 days earlier (at approximately 26 percent kernel moisture) than the usual date for starting to harvest with a corn picker. While this permits harvesting during a period of relatively low field loss, it is believed that this feature alone is not the ultimate solution to the problem of reducing field losses to the lowest economical level. There still remains the need for some means for harvesting fallen ears and for preventing the loss of corn shelled by the ear-snapping unit.

It is well known that changes in corn-production practices are intertwined with economic elements and technological advancements. It appears now that these factors are favorable for the change from the practice of harvesting and conditioning ear corn to the practice of harvesting and conditioning shelled corn. Real progress is being made in developing grain-drying methods and equipment, developing ways and means for satisfying the demand for higher labor efficiency, making possible better timing of the harvesting operations, providing ways and means for conditioning grain for better storage, and in developing ways and means for lowering machine costs per unit harvested.

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Laboratory Studies of Corn Combining

Geo. E. Pickard
Member ASAE

THE first experiment at the University of Illinois, on harvesting corn by combine was made in 1950. A few ears of corn were tossed into a combine and the cob came out whole and completely stripped of corn. In that first shot in the dark an almost ideal cylinder and concave adjustment was made—a good example of beginner's luck. Encouraged by this trial the first laboratory studies of cylinder shelling were set up and continued through 1952. (1)*

In 1953 a pull-type combine was equipped with a gathering and feeding device to harvest one row of corn, putting the entire plant through the machine. (2) The principal results of that year's work were to confirm the belief that the cylinder and cleaning shoe of a combine are adequate for corn shelling and cleaning, but that the combine may not be able to handle the entire corn plant.

In view of the encouraging industry activity in the corn-combining field, it was decided to leave the whole problem of feeding devices to the individual manufacturers and to concentrate on more fundamental aspects of the problem—to provide information of a type that would be useful to all combine builders. A rasp-bar cylinder and a channel-bar concave were used in the studies from 1950 to 1954. Decision was then made to compare various cylinder and concave-bar arrangements as to shelling efficiency and kernel damage

The author—GEO. E. PICKARD—is professor in agricultural engineering, University of Illinois.

*Numbers in parentheses refer to the appended references.

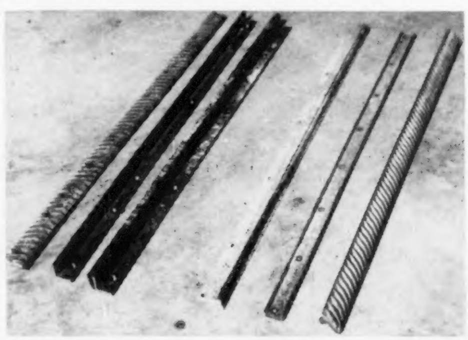

Fig. 1 Combinations of cylinder and concave bars used in 108 corn shelling tests in 1954

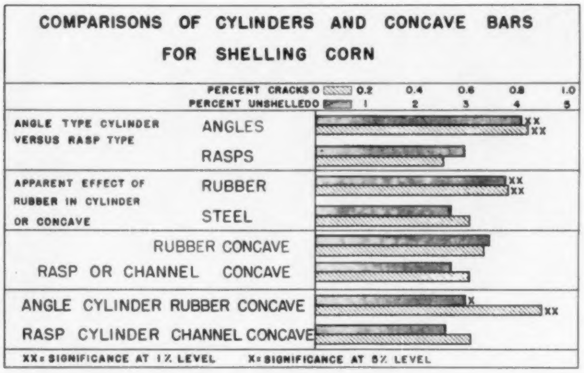

Fig. 2 Comparison results of various bars in respect to shelling and damage

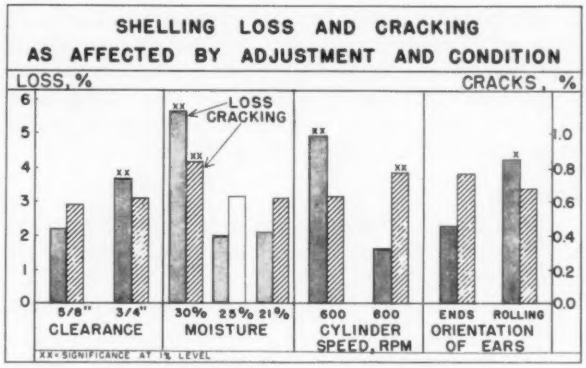

Fig. 3 Effect of cylinder clearance, kernel moisture, cylinder speed and ear orientation upon shelling efficiency and kernel damage

and to correlate these effects with other variables, such as cylinder speed, concave clearance, moisture content of corn, and orientation of the ears.

Cylinder and Concave Comparisons

The following combinations of cylinder and concave bars were studied:

- Steel angle cylinder bars and rubber concave bars
- Rubber-covered angle cylinder bars and rubber concave bars
- Steel angle cylinder bars and rasp-type concave bars
- Rasp-type cylinder bars and rubber concave bars
- Rasp-type cylinder bars and channel concave bars
- Rasp-type cylinder bars and rasp-type concave bars.

The various bars are shown in Fig. 1. One hundred eight tests were run, one-third at each of three kernel-moisture contents, 30, 25 and 21 percent. Laboratory apparatus consisted essentially of a cylinder and concave set up for ease of clearance and speed adjustment. The corn ears with the husks on were fed into the cylinder down an inclined chute, and the cobs and shelled corn were collected in a box at the rear. Insect-damaged kernels made it difficult to identify machine damage, so the amount of cracked kernel material passing a 10/64 sieve was used as a measure of relative damage in comparing the various cylinder and concave arrangements.

Shelling and Damage Comparisons

The effects of the several variables on shelling efficiency and kernel damage were evaluated statistically by analysis of variance, and in Figs. 2 and 3 the degree of significance of the comparisons is shown. Many of the results are significant at the 1 percent level of probability, indicating a high level of dependability in the data.

The angle-bar cylinder with rasp-bar concave shelled so poorly that the results of this combination have been left out of all comparisons.

Fig. 2 shows the comparisons of bars. In comparing angle-type cylinders vs. rasp bars, it will be seen that at these clearances angles left 4.1 percent unshelled compared with 3.0 percent left by the rasps, and the angles cracked almost twice as much corn. Both of these comparisons were highly significant statistically.

The next comparison is described as "apparent effect of rubber in cylinder or concave" since, although it appears to prove that rubber shells more poorly and cracks more corn, the next comparison between rubber and channel concaves shows no significant difference. Hence, the poor results for rubber compared with steel in the second comparison is in reality due to the effect of angles.

The fourth comparison of Fig. 2 is the rasp cylinder and channel concave compared with the angle and rubber combination. The efficiency difference between 2.7 and 3.0 percent is not significant, but the damage spread between 0.63 and 0.92 percent is considerable.

All of these loss figures are high. This is true because over-all comparisons include unfavorable variables of kernel moisture, cylinder speed and concave clearance. When average kernel moisture and only suitable adjustments are used, the percentage of corn unshelled drops to about 0.8 percent.

Effects of Variables Other Than Bars

Fig. 3 shows how cylinder clearance, kernel moisture, cylinder speed and ear orientation affect shelling efficiency and kernel damage. These are averages for all cylinder and concave bar arrangements. As would be expected, clearance is important. A reduction from ¾ to ⅝-in drops the corn loss from 3¾ to 2¼ percent. However, this tightening down is not accompanied by any significant increase in cracking. These spacings and comparisons are for the rasp-type cylinder only. A spacing of 9/16-in was used for all angle-type cylinder tests.

The moisture comparisons reveal that both loss and cracking are rather high at 30 percent. However, the curves have already flattened out at 25 percent, showing that the farmer need not wait long for harvesting after the corn is below 30 percent.

The comparisons in cylinder speed between 600 and 800 rpm indicate a more critical adjustment than earlier tests had indicated. This speed increase drops the corn loss from 5 to 1.6 percent while increasing the kernel damage by only 0.12 percent, from 0.65 to 0.77.

The relationship between shelling and orientation of the ears appears to be of only academic interest, since the method of feeding will vary. While shelling efficiency is improved by endwise feeding, the percentage of cracking is increased, so it would appear difficult to choose one method or the other. However, since the ears go through the cylinder most readily in the rolling sense, it seems desirable to attempt to improve the shelling in this orientation.

Future Plans

The program of evaluation of cylinders and concaves will be continued. The rasp-bar cylinder with grate-type

concave common in self-propelled combines will be studied along with spike-tooth cylinders, and sufficient repeats on 1954 cylinder and concave types will be made to provide comparisons. The number of other variables, such as clearance and speed, will be reduced to permit study of the larger number of cylinder and concave types.

Summary

1 Rasp-type cylinders appear to be superior to angle-bar cylinders in shelling efficiency and kernel damage at the clearances used.

2 Rubber in cylinder or concave appears to have little effect on shelling or cracking.

3 Concave clearance of ⅝ in is more desirable than ¾ in for rasp-type cylinders.

4 Critical kernel moisture falls between 30 and 25 percent.

5 Cylinder speed of 800 rpm (3100 fpm at the periphery) is more desirable than 600 rpm (2350 fpm).

6 Orientation of the ears on entering the cylinder is not important.

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Field Tests of Combines in Corn

John R. Goss, Roy Bainer and R. G. Curley
Assoc. Member ASAE Fellow ASAE Assoc. Member ASAE
and D. G. Smeltzer

STUDIES at the University of California of two combines equipped with rasp-bar cylinders indicate that the ordinary grain combine is well suited for shelling corn under California conditions. A total of 66 tests were run in a field planted to a hybrid variety in late May. The average yield was 3600 lb of shelled corn per acre. The tests were conducted between October 20 and November 4, 1954. During this period the kernel moisture ranged from 18.5 to 12.1 percent. Strong winds during the latter part of the test period caused considerable lodging and stalk breakage. One machine was of the self-propelled type equipped with a stalk-gathering attachment (Fig. 1); the other was a straight-through-type machine with an ear-snapping unit attached (Fig. 2). Both experimental gathering units as well as the straight-through combine were made available for test purposes by their respective manufacturers. Each handled two rows of corn planted on 40-in centers.

Test Procedure

Each test covered 1/100 acre. Before harvest the numbers of ear-bearing stalks and lodged ear-bearing stalks were

The authors—JOHN R. GOSS, ROY BAINER, R. G. CURLEY and D. G. SMELTZER—are, respectively, assistant specialist, agricultural engineer, extension agricultural engineer, in agricultural engineering, and assistant professor of agronomy, University of California (Davis).

Acknowledgment: The assistance of W. M. Lawson and W. N. King, farm advisors, California Agricultural Extension Service, and of George Abernathy and Bruce Campbell, students at the University of California (Davis) is acknowledged. The authors also wish to thank Wim Lely of the Orland Machine Works, Orland, Calif., and the management of the International Harvester Co. for making available the gathering units and one harvester used in the tests.

Fig. 1 Whole-stalk gathering unit attached to a self-propelled combine. The stalks were cut with a conventional cutter bar and then conveyed to the cylinder on a draper with the cut ends leading. The three beaters above the draper assist in the feeding operation

established, and all loose ears and shelled corn removed from the ground. The harvesting was done at two speeds—about 1 mph and 2 mph—and elapsed time for the run recorded. Two 9 x 15-ft canvas sheets were pulled behind the machine: one to catch material discharged by the cleaning shoe; the other for material discharged from the straw walker. The shelled corn was caught at the clean grain elevator. Ear corn lost by the gathering unit was determined by gleaning the test area. Shelled corn lost by the gathering unit was computed from gleanings within a 40 x 80-in frame placed at five random locations within the test area.

The material caught on the two canvases was cleaned in the laboratory to determine the free seed loss from the straw carrier and shoe as well as the unshelled corn loss from the cylinder. Two representative samples of shelled corn caught at the clean grain elevator were taken after the completion of each test. One sample was for moisture determination with a Tag-Heppenstal moisture meter; the second sample was for determination of the percentage of cracked corn and foreign material (by screening according to the procedure outlined in the "Handbook of Official Grain Standards of the United States.").

Losses are reported on a shelled-corn basis.

Fig. 2 Snapping roll gathering unit attached to a straight-through-type combine. Cylinder equipped with filler plates between the bars. Ears of corn are removed from the stalks by the action of star-shaped snapping rolls and stripper plates and then fed directly into the cylinder

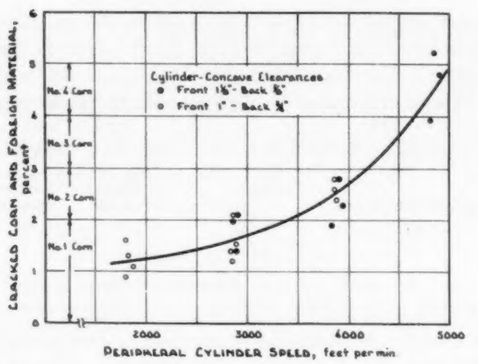

Fig. 3 Relation of the percentage of cracked corn and foreign material to cylinder speed for the self-propelled unit. Kernel moisture content was 13.0 to 15.2 percent. Feed rate into the combine, not including the shelled corn, was 50 to 315 lb per min

Results

The results of grading the corn shelled in the self-propelled combine are shown in Fig. 3. Corn shelled at a cylinder speed of 3800 fpm or less graded No. 2 or better. With the straight-through machine at a cylinder speed of 2900 fpm or less, the samples from 24 of the 27 tests contained 2 percent or less of cracked corn and foreign matter, determined by standard grading technique.

Shelling performance of the cylinder was further evaluated by laboratory analysis of the percent by weight of mechanically damaged kernels—chipped or broken—that did not pass through the 12/64-in round-hole screen used in the commercial grading test. This type of damage does not affect the commercial grade of corn directly, but the presence of such kernels may complicate the storage of wet corn and may have an adverse effect on the quality of corn harvested for seed. Figs. 4 and 5 show that there was a definite correlation between cylinder speed and this type of mechanical damage. The differences in damage are significant

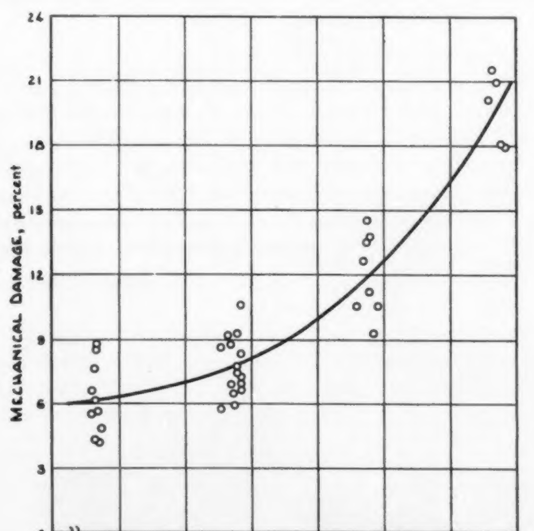

Fig. 4 The effect of cylinder speed on percent of mechanically damaged corn for the self-propelled unit. Cylinder-concave clearance was ¾ to 1⅛ in at front and ⅜ to ⅞ in at rear. Kernel moisture content was 12.4 to 18.5 percent. Feed rate into the combine, not including the shelled corn, was 125 to 370 lb per min

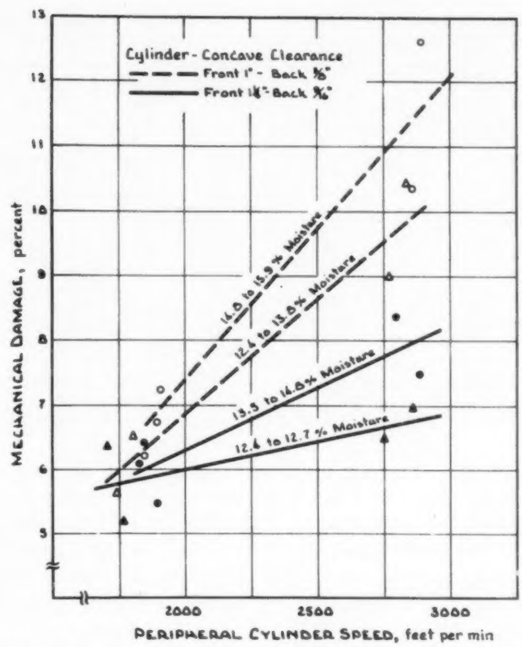

Fig. 5 The effect of cylinder speed on the percent of mechanically damaged corn for the straight-though combine. Feed rate into the combine, not including the shelled corn was 33 to 90 lb per min. Feed rates above 60 lb per min—usually 2 mph forward speed—are generally the points below the graph lines

among the four ranges of cylinder speeds shown in Fig. 4 and the two ranges of cylinder speeds shown in Fig. 5. The vertical scatter of points within cylinder-speed ranges cannot be accounted for consistently by kernel moisture and cylinder-concave clearance, as is shown in Fig. 5. At the average cylinder-speed range of 2800 fpm (Fig. 5) the effect of these two variables is rather definite, but at the lower cylinder-speed range the relationship is rather obscure. This latter situation is typical of the data in Fig. 4. Had tests been conducted with the straight-through combine over a range of cylinder speeds similar to the tests with the self-propelled combine, the curves of Fig. 5 undoubtedly would not be linear. Limited field tests conducted in several areas of the

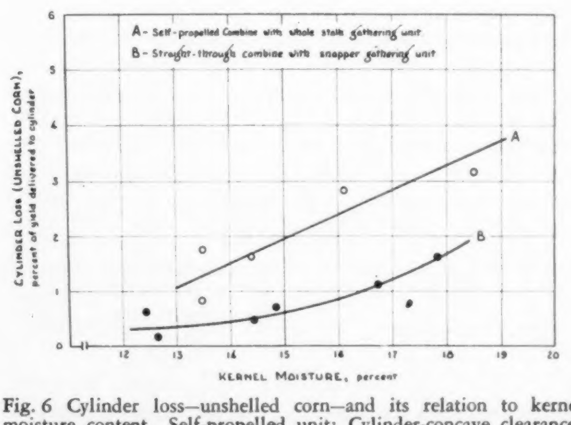

Fig. 6 Cylinder loss—unshelled corn—and its relation to kernel moisture content. Self-propelled unit: Cylinder-concave clearances were ¾ to 1 in at front and ⅜ to ¾ in at rear; cylinder speed was 2760 to 2905 fpm; feed rate, not including corn, was 190 to 370 lb per min. Straight-through combine: Cylinder-concave clearances were 1¼ in at front and 9/16 in at rear; cylinder speed was 2750 to 2865 fpm; feed rate, not including corn, was 37 to 85 lb per min

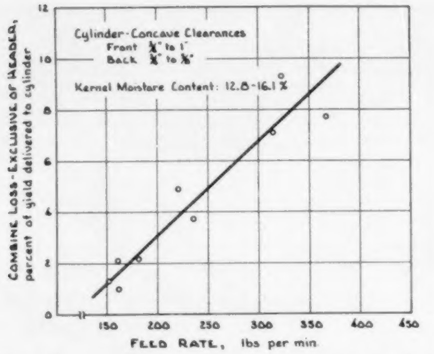

Fig. 7 Effect of rate of feeding, not including corn, into the self-propelled combine on the cylinder and separation loss—combine loss—exclusive of header losses. Cylinder speed was 2840 to 2905 fpm

state before the tests at Davis indicate that the average values presented in Figs. 4 and 5 are higher than normal. This probably is because of an infestation of Fusarium ear rot in the field where the tests were conducted. In the laboratory analysis for mechanically damaged kernels, steps were taken to minimize the influence of disease damaged kernels on the measurement of mechanical damage.

Kernel moisture had some influence on cylinder loss. The trend, indicated by a limited amount of data, is shown in Fig. 6. The spread between the curves for the two types of combines and gathering units probably is the result of considerable differences in feed rates per unit length of cylinder-concave width.

Separation loss for the self-propelled combine with the whole-stalk gathering attachment definitely was influenced by the rate of feeding into the combine. Fig. 7 shows the combined cylinder and separation loss for selected tests on this unit. Within the range of feed rates—40 to 110 lb per min—encountered in the tests on the straight-through combine with the snapping-roll attachment, this variable had only a slight effect on separation loss. With an average cylinder speed of 2800 fpm and a cylinder-concave clearance of 1 in at the front and ⅜ in at the rear, the average of cylinder and separation losses combined was 2 percent of the yield delivered to the cylinder.

Ear corn loss data for both gathering units indicate that a high percentage of this loss was on lodged or down stalks. The number of ears lost also depended on the forward speed of the combine and the design of the gathering unit. Assuming that the gathering units were 100 percent efficient in delivering standing corn to the cylinder, the efficiency of recovering down and lodged ears—based on percent of ears down or lodged—is given in Table 1. All 66 tests furnished the figures of this table, and represent a range of 2 to 54 percent of down and lodged ear bearing stalks.

TABLE 1. GATHERING UNIT EFFICIENCY IN PERCENT FOR THE RECOVERY OF DOWN CORN

Average forward speed	Type of gathering unit: Whole stalk	Snapping roll
1.2 mph	54	71
2.1 "	42	64

The shelled corn loss from the whole-stalk gathering unit ranged from 0.03 to 0.80 percent of the total yield, averaging 0.30 percent for all tests. Average values for similar data on the snapping roll unit are given in Table 2. At the end of the tests it was discovered that one of the gathering chains carried shelled corn from the cylinder housing down onto the ground. The losses given in Table 2 include this loss and the shelling loss from the snapping rolls. The shelled corn loss data for both the gathering units

TABLE 2. SNAPPING ROLL UNIT SHELLED CORN LOSS

Average forward speed	Loss, percent of total yield: Standing corn	Harvesting with lodge	Harvesting against lodge
1.2 mph	2.2	2.9	1.5
2.1 "	1.5	2.3	1.8

tested indicate only a slight dependence upon kernel moisture content, and that this dependence is indirect rather than direct, contrary to most of the literature on mechanical corn harvesting.

In the tests reported herein the best performance with both combines was obtained when the cylinder was operated at a speed of about 2800 fpm. At that speed the cylinder-concave clearance on the self-propelled unit was 1 to 1⅛ in at the front and ¾ to 1 in at the rear. Similarly, on the straight-through combine the clearance was 1 in at the front and ⅜ in at the rear. The tests and the observations made during actual harvesting both showed conclusively that the major problem in harvesting corn with adapted combines was the delivery of the unshelled grain to the cylinder without loss of corn, primarily ear corn on down or lodged stalks.

Attachments for Combining Corn

(Deere and Co.)

C. S. Morrison
Member ASAE

IN NOVEMBER 1952 the product development department of Deere and Company initiated a corn-harvesting project in cooperation with the John Deere Harvester Works and the John Deere Des Moines Works, the objectives of which were *(a)* to improve the efficiency of corn-harvesting equipment and *(b)* to develop field-shelling corn-harvester equipment.

Combine Efficiency Tests

The use of a combine cylinder to shell corn was reported by Pickard and Hopkins (1)*. It was decided that we should investigate the efficiency of the John Deere No. 55 combine in corn during the 1953 season. A glass-sided combine was used in these stationary tests (Fig. 1). Hand-

The author—C. S. Morrison—is manager, product development department, Deere and Company.

*Numbers in parentheses refer to the appended references.

Fig. 1 Glass-sided combine used in stationary tests

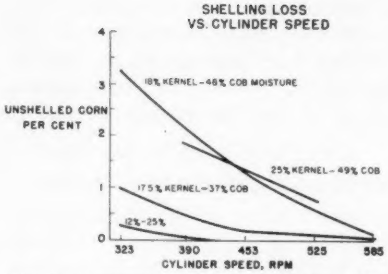

Fig. 2 A conventional 22-in diameter, 8-bar rasp cylinder operated at five speeds to obtain shelling loss data at four moisture contents

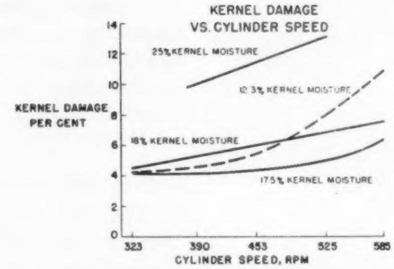

Fig. 3 Under same test conditions as in Fig. 2 showed that kernel damage increased rapidly as the cylinder speed increased above 453 rpm

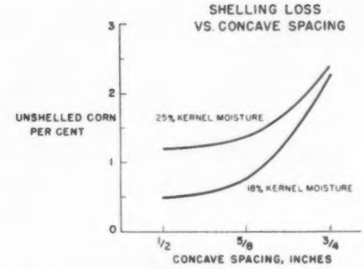

Fig. 4 Shelling losses were almost identical at ½-in and ⅝-in spacing from the cylinder to the rear concave bar

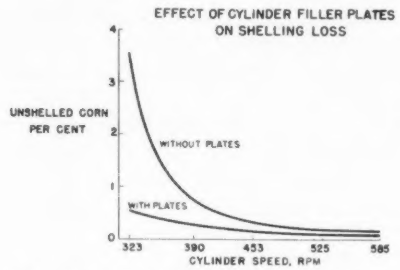

Fig. 5 Shelling losses were reduced at all cylinder speeds when filler plates were used

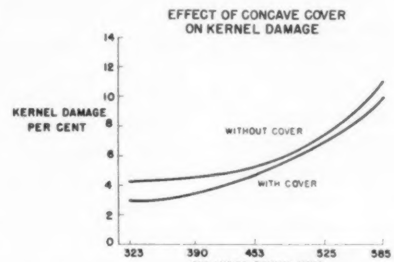

Fig. 6 A steel plate covering the front section of the concave reduced kernel damage slightly

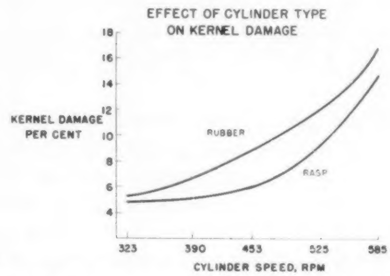

Fig.7 The conventional rasp-bar cylinder resulted in less kernel damage than did special rubber-covered equipment

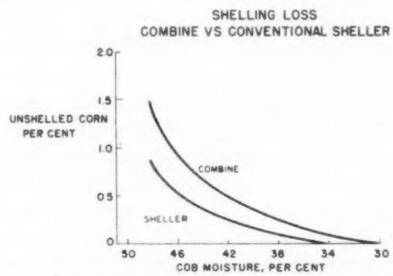

Fig. 8 Losses with combine were slightly greater than with conventional sheller, but the difference never exceeded 0.5 percent

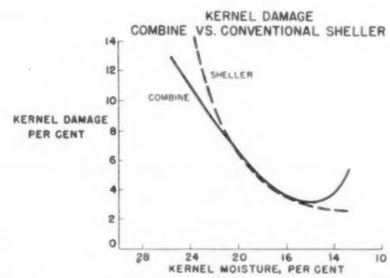

Fig. 9 In the moisture range of 15 to 20 percent, there was no appreciable difference in kernel damage between combine and sheller

snapped ears with all of the husk intact were fed into the combine cylinder by means of a conveyor. Each reported test was the average of two individual runs consisting of a 30-ear sample. The rate of feeding was comparable to that encountered in harvesting 100 bu-per-acre corn at a ground speed of 3.5 mph.

The threshing losses were calculated on a percentage-by-weight basis. High-speed movie photography was used also as a means of studying the harvesting operation. Test runs were made throughout the harvest season at various cob and kernel moisture contents.

Shelling Loss vs. Cylinder Speed

The conventional 22-in diameter, 8-bar rasp cylinder was operated at five speeds to obtain shelling loss data at four moisture contents (Fig.2). The concave-to-cylinder spacing was 1¼ in at the front and ⅜ in at the rear of the concave. The shelling loss, or percentage of unshelled corn, decreased with increasing cylinder speed. Generally acceptable shelling efficiencies were obtained at cylinder speeds of 453 rpm (2610 fpm) or above.

It was noted that samples of similar cob moisture content were shelled with similar efficiency. The data suggest that shelling loss was a direct function of the cob moisture content. No definite correlation was shown between shelling loss and the kernel moisture content. This means that the cob moisture content must be known if the shelling loss is to be predicted for a particular field condition.

Kernel Damage vs. Cylinder Speed

Under the same test conditions as above, it was found that kernel damage increased rather rapidly as the cylinder speed was increased above 453 rpm (Fig. 3). Kernel damage was determined on a weight basis by visual detection of mechanical damage to the seed coat. The kernel damage generally was higher at the higher kernel moisture contents.

Shelling Loss vs. Concave Spacing

Under the test condtions, the shelling losses were almost identical at ½ in and ⅝ in spacing from the cylinder to the rear concave bar (Fig. 4). The shelling loss increased at the ¾ in concave spacing. The spacing at the front bar of the concave was 1¼ in for all tests.

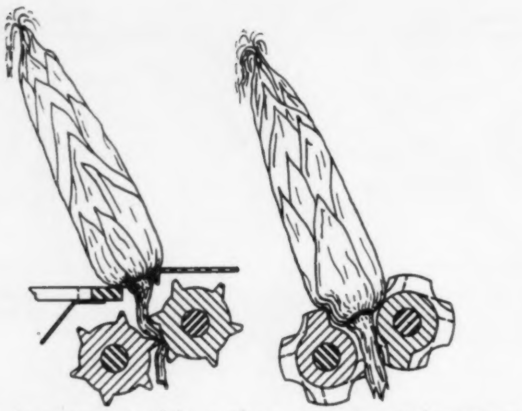

Fig. 10 Snapping unit *(left)* used on new corn attachment prevents direct contact of the ear with the fluted snapping rolls. System on right shows direct contact of ear with conventional snapping rolls

Effect of Cylinder Filler Plates on Shelling Loss

It was reported by Pickard and Hopkins (1) that closing the open space between cylinder bars or increasing the number of bars decreased shelling losses.

The 22-in diameter cylinder with eight rasp bars was tested at 17.5 percent kernel moisture and 37 percent cob moisture. The shelling losses were found to be reduced at all cylinder speeds when filler plates were used (Fig. 5). However, at speeds above 453 rpm, it was concluded that the use of filler plates would not be justified for this particular crop condition. The inconvenience of installing or removing the cylinder filler plates would appear to outweigh the slight reduction in shelling loss. The effect of the filler plates upon kernel damage was investigated and found to be negligible.

Effect of Concave Cover Plate on Kernel Damage

A steel plate covering the front section of the concave was used in an attempt to reduce kernel damage (Fig. 6). In this test the kernel moisture was 12 percent and the cob moisture was 11 percent. The use of the concave cover plate reduced the kernel damage slightly, but probably the improvement would not justify the installation of this special attachment. The concave cover plate had no influence on the shelling loss.

Effect of Cylinder Type on Kernel Damage

A special cylinder equipped with rubber-covered angle bars was used in conjunction with a rubber-covered concave cover plate for one series of kernel damage tests (Fig. 7). The kernel moisture was 17 percent and the cob moisture was 15 percent. The conventional rasp-bar cylinder resulted in less kernel damage than did the special rubber-covered equipment.

Shelling Loss, Combine vs. Conventional Sheller

In the final analysis, the decision to adapt the John Deere No. 45 combine for corn harvesting was largely dependent upon a shelling loss and kernel damage comparison with a conventional corn sheller. The John Deere No. 7 sheller was used for this comparison since it was believed to have suitable capacity for 2-row field shelling. For these tests the combine was operated at 453-rpm cylinder speed and with ⅝-in concave spacing irrespective of the crop conditions.

It was found that shelling losses with the combine were slightly greater than with the conventional sheller, though this difference never exceeded 0.5 percent (Fig. 8). Below approximately 47 percent cob moisture, the combine was found to have a shelling efficiency of at least 99 percent in all tests.

Kernel Damage, Combine vs. Conventional Sheller

From the above-mentioned series of tests comparing the combine with the conventional corn sheller, the kernel damage data were also plotted (Fig. 9). In the moisture range for which the conventional sheller primarily was designed (below 15 percent kernel moisture), the combine resulted in greater kernel damage than the sheller. In the moisture range of approximately 15 to 20 percent, there was no appreciable difference in kernel damage with the two machines. Above approximately 20 percent kernel moisture content, the combine resulted in much less kernel damage than the conventional sheller.

The moisture content of corn to be field shelled is almost always above 15 percent; it is usually above 20 percent; and it may be as high as 30 percent. Therefore, it was concluded that the combine cylinder was well adapted for this service.

No. 10 Corn Attachment

Concurrently with the combine efficiency tests conducted in 1953, two experimental corn attachments were field tested on self-propelled combines. These corn attachments embodied a special snapping unit (Fig. 10), which consisted of a pair of aggressive traction rolls with stationary snapping surfaces arranged above the rolls. This unit prevents direct contact of the ear with the fluted snapping rolls. Tests have proven that direct contact of the ear with the snapping rolls is responsible for most of the field loss of shelled corn observed with conventional pickers. Early in the harvest season, the major portion of the corn picker losses are in the form of shelled corn left in the field (2, 3).

In the No. 10 corn attachment, most of the husks remain on the ear. The amount of inadvertent shelling during the snapping operation is reduced. The shelling due to the ear striking the gathering sheets, gathering chains, etc., is minimized. The husks remaining on the ears present no

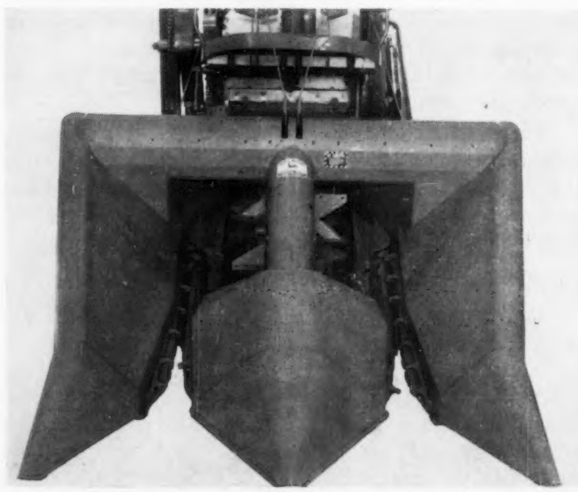

Fig. 11 Front view of the No. 10 corn attachment

problem in a combine which has ample shelling and separating capacity. Actual field tests with the No. 10 attachment have shown an average savings of 50 percent of the usual shelled corn loss at the snapping rolls with savings of 75 percent being not at all unusual.

Adaptation of the Combine

The No. 45 combine is a self-propelled machine normally equipped with an 8- or 10-ft grain platform. This combine was developed concurrently with the development of the No. 10 corn attachment. Therefore, features in the combine design which make this machine suited for the corn harvesting operation were included. The threshing concave, the beater behind the cylinder, and the straw walker construction were modified mainly to provide adequate strength for harvesting corn. The same attaching mountings and the same two hydraulic-lift cylinders are used for both harvesting operations. The only other connection between the corn attachment and the combine is a roller-chain drive from the right-hand end of the combine cylinder shaft. This source of power is practical since the cylinder speed is seldom changed during the corn-harvest season.

Installation of the No. 10 attachment on the combine is simplified by use of an adjustable stand which is built into the corn attachment. The attachment can be removed and the grain platform installed in less than one hour. Adjustment of the cylinder speed, the concave spacing, and the sieve openings are the only other changes required when changing from corn to small grain or soybeans.

Advantages of Corn Combining

Harvesting corn with the corn attachment on the combine has many advantages as compared to either harvesting ear corn or field shelling by other methods:

1 Cost of corn combining is approximately the same as for picking ear corn; saves one operation if the crop is to be shelled anyway.

2 Shelled corn requires only approximately one-half as much storage space as for ear corn.

3 Owners report buying shelled-corn storage and forced-air driers for the same investment as for ear-corn storage without a drier.

4 Shelled corn is easier to handle by mechanical methods, less bulk to transport.

5 Earlier harvest often means better market prices and better harvest weather.

6 Reduced field losses because of earlier harvest and more efficient harvesting equipment.

7 More time for fall plowing or seeding winter wheat following the corn harvest.

8 Shelled corn is dried more economically by forced air than is ear corn.

9 Use of drying equipment is good crop insurance in the northern portion of the corn belt.

10 Cobs and stalks are left in the field.

11 Reduced investment in harvesting equipment.

12 Operator sits high above the gathering unit with excellent view, away from dust, noise, and engine heat.

13 Variable ground speed permits instant adjustment of rate of travel to meet varying conditions. Therefore, more acres are covered per day with less of a safety hazard due to plugging of the harvesting machine.

14 Self-propelled machine is easily maneuverable and will negotiate wet field conditions better than other corn-harvesting equipment.

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Attachments for Combining Corn

(International Harvester Co.)

Ray Barkstrom
Member ASAE

CONTINUED development of attachments for combines used to harvest corn shows considerable promise. The efforts of our company this past year were directed principally toward utilizing snapper-type corn picker units in conjunction with standard harvester threshers. The design of the snapper or stripper-type picker unit is such that comparatively little shelling normally takes place in the snapping rolls (Fig. 1).

Two approaches in this direction were made: *(a)* a large self-propelled machine equipped with a standard rub-bar cylinder and rotary-type straw walkers, *(b)* a small pull-type combine having a rub-bar cylinder and unit type of straw rack.

For purposes of comparison, however, a third unit was constructed using a feeder type principle wherein the stalks are severed intact at some distance above the ground and transported with the ears in place to the separator itself.

This last approach presents the usual problems of, first, controlling the stalks after cutting without an enormous amount of mechanism, and, second, handling the entire field of corn on a straw rack in the separator itself.

For ordinary crop conditions, the snapping rolls are set as close together as possible without touching at any point. The snapping roll spacing is adjustable from a spacing as narrow as desired to a spacing wide enough to accommodate normal stalk variations in increments of ⅛ in to a maximum of 1 in. Both snapping rolls and stripper plates are set just wide enough to snap the ears and yet cause little or no breakage of the stalks themselves, or an excessive amount of corn leaves or trash.

The action of the rolls and the stripper bar are such that the ear is broken away from the stalk by the stripper bar before any entry of the ear into the roll itself takes place. In addition, the star-type roll will handle either dry or green stalks efficiently. Operating speed of the rolls is 1240 to 1600 rpm as compared with the normal speed of the pocket-type snapping roll of 590 to 710 rpm.

The author—RAY BARKSTROM—is assistant chief engineer, International Harvester Co., East Moline, Ill.

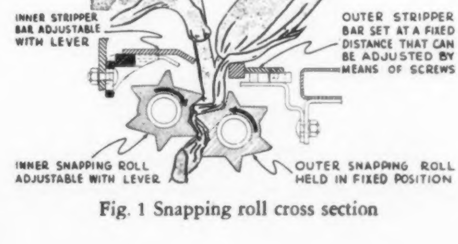

Fig. 1 Snapping roll cross section

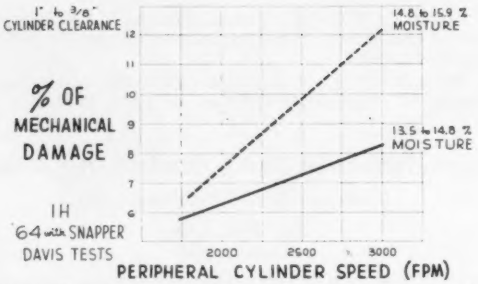

Fig. 2 *(Left)* Kernel damage with cylinder clearance of 1 to ⅜ in

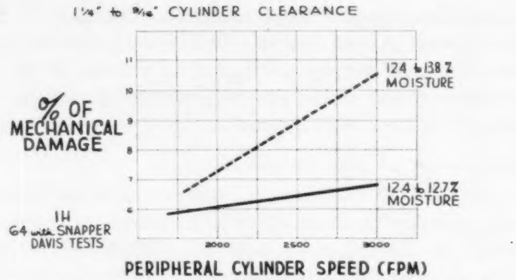

Fig. 3 *(Right)* Kernel damage with cylinder clearance of 1¼ to 9/16 in

The first combining tests were run in July 1954, in the southeastern section of California. Corn yields ran from 75 to 90 bu per acre with heavy foliage and stalks ranging from 10 to 12 ft in height. Moisture content at this particular point ranged from 12 to 18 percent in the ears. In contrast, corn of comparable yield was combined later in October 1954 in Illinois with moisture content as high as 27 percent in the kernels with acceptable results.

Normally, peripheral speed of the cylinder was held to about 2800 fpm during the test runs. Tests on the pull-type machine as shown in Figs. 2 and 3 show the trend that a closer cylinder-to-concave setting results in a rising percentage of mechanical damage.

One criticism that has been raised against usage of the combine cylinder as a means of shelling corn is the apparently high rate of damaged kernels caused by the cylinder itself. Actual tests of cracked corn, however, fell below 2 percent at 2800 fpm cylinder speed. Early observations indicated that combines had equal or greater capacity for handling corn in the field than the picker and sheller combination as presently built and used.

With a moisture content ranging from 9 to 21 percent, tests of shelled corn loss ran from 0.66 percent to a maximum of 3.6 percent with an over-all average of 1.95 percent for the small pull-type machine. Examination disclosed that this loss did not occur in the snapping rolls, but was the result of a backfeeding from one of the gatherer chains that picked up kernels from the tailings return of the combine. Design changes later corrected this condition. Ear corn loss showed fairly satisfactory results with higher losses in down and lodged ears than in standing corn.

The feeder-type header as used on the pull-type machine showed a slightly improved condition for shelled corn loss averaging 0.72 percent as compared with 1.95 percent, but a high rate of ear corn loss as compared with the snapper type gatherer units. Losses in this category almost trebled, showing 6.03 percent for the snapper unit as compared with 16.88 percent for the auger type unit. Straw-walker losses

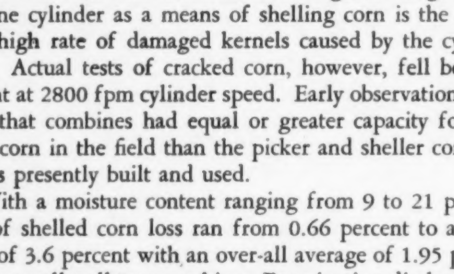

Fig. 4 Federal grading cleanout as affected by kernel moisture and cylinder speed

were also considerably greater in this type of unit averaging 6.03 percent as compared with only 1.95 percent for the snapper-type units. No significant difference in shoe loss could be detected between either type of machine.

The self-propelled machine as compared with the pull-type machines appears to offer a more satisfactory approach and a more versatile type of application. Adaptation of standard snapper units presents far less of a problem and offers an easier approach for feed-in to the cylinder. Discharge from the snapping units into a central feeder is not too difficult a transition and offers better opportunity for control of the material into the machine than the approach on the pull-type machines.

Attachments for Combining Corn
(Allis-Chalmers Mfg. Co.)

C. J. Scranton
Member ASAE

IN THE fall of 1936, Allis-Chalmers decided to do some development work on a field corn-shelling attachment to be adapted to our then 5-ft Model 60 harvester. At this early date we were well aware of work which had been done previously by others. We also had records of field corn shelling in South America and Europe. Our files showed many experiments by farmers with both field corn and popcorn.

Our first efforts in development were directed to a limited modification of the standard grain machine to make it possible to process the entire plant. The stalks were cut off by the standard sickle, conveyed to the cylinder, and the leaves, tassels, and husks were then stripped off the stalk by the action of the cylinder at the same time the corn was shelled. The shelled corn was cleaned by the standard separator mechanism and conveyed to the grain-storage tank. The lighter material was picked up by a suction fan and spout mounted over the straw rack and blown into a two-wheel dump cart which was drawn by the harvester. The stalks, well stripped, come out of the machine in short lengths and they, along with the cobs, were carried out over the straw rack and deposited on the ground.

With this unit we attempted to handle two rows of corn with the standard grain-feeding canvas, a larger diameter reel than normal, and the standard reciprocating cutter bar. It soon developed that the power requirements were too high for a 2-plow tractor, that the canvas carrier was entirely too fragile, and that the reel, even with increased diameter, was inadequate. Furthermore, the standard grain-cutting

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Valving Air Flow in Drying Bins

Edward A. Kazarian and **Carl W. Hall**
Assoc. Member ASAE   Member ASAE

Heavy, brown wrapping paper serves as a valve against short-circuiting of air flow when drying grain in partially filled bins

WITH the advent of quonset-type drying bins, methods for ventilating these bins when partially filled present a problem. This problem is brought about by the irregular shape of the building. It is conceivable that in some years a farmer will not fill his bin to capacity and therefore cannot obtain uniform air flow and uniform drying.

In a partially filled quonset bin, the air will be short-circuited through the grain mass directly over the duct while grain located at the sides of the duct will not receive adequate ventilation. This non-uniformity of air flow is greatest with small amounts of grain in the bin over a center duct.

One method of ventilating such a bin is to cover the mass of grain immediately over the duct through which the air is short-circuited and thereby divert part of the air flow to the remaining grain. This method is known as "valving". It is understood that as valving is applied on the grain, the static pressure will be increased and the total air flow through the bin will be reduced. However, in a partially filled bin the total air flow can be sacrificed to obtain uniform air flow throughout the grain. Valving is easy to accomplish when the duct is under a vacuum.

During the summer of 1954, a quonset research building located at East Lansing, Mich., was used to conduct tests on the ventilation of wheat. The primary purpose of the test was to determine the effects and value of valving as a means of uniformly ventilating a partially filled bin.

The quonset used for the tests is a 16 x 32-ft building with a 4-ft instrument room at one end of the building. The instrument room is partitioned with a ¾-in plywood bulkhead, in which pressure taps are located on the corners of 8-in squares. An 18-in semipressure fan supplies the building with an exhaust system of ventilation. The capacity of the bin is 2400 bu.

Procedure

The wheat was delivered to the bin at a rate of two truck loads per day which averaged about 6 tons each. The farmer's combines would unload into farm wagons from which the wheat was transferred to the truck and hauled to the bin. The wheat was then shoveled from the truck into a farm elevator which conveyed the grain to the hatch openings of the quonset. A standard 5-ft grain probe was used to secure samples from each truck load. The samples were checked for moisture content and test weight.

After two truck loads of grain were placed in the bin, the wheat was smoothed to give a nearly level surface. The fan was operated and pressure readings were obtained from the pressure taps. A Vernon micromanometer was used to measure the static pressure in inches of water.

The material used for the purpose of valving was heavy, brown wrapping paper. The paper came in 3-ft widths and was cut in 28-ft lengths to fit over the entire length of the grain surface. First one sheet of paper was placed directly on the grain surface and centered directly over the duct. When the fan was operating, the paper was held in place by the suction pressure created by the fan. Pressure readings were obtained and then the valving was increased to three sheets of paper. The paper was lapped 2 in to prevent air leakage. Pressure readings were taken again. Finally, one sheet of paper was removed and the remaining two centered over the duct and pressures read again. This test

TABLE 1. PERCENT OF WHEAT RECEIVING AIR FLOW IN EXCESS OF 3, 4, 5 CFM PER BUSHEL

Center depth of grain, including duct (inches)	Amount of grain in bin (bushels)	Sheets of Valving (3-ft sheets)	Percent receiving more than 3 cfm/bu	Percent receiving more than 4 cfm/bu	Percent receiving more than 5 cfm/bu
27	522	0	33.0	30.6	29.0
27	522	1	51.5	49.7	48.6
27	522	2	58.2	55.4	54.2
27	522	3	66.4	64.5	63.3
38	890	0	64.3	62.8	61.6
38	890	1	70.6	69.0	67.8
38	890	2	79.8	78.8	70.9
38	890	3	94.6	91.1	89.2
55	1315	0	92.7	85.3	79.2
55	1315	1	95.1	90.5	86.5
55	1315	2	93.1	91.3	90.7
55	1315	3	100.0	98.3	94.5
72	1743	0	96.5	94.3	92.7
72	1743	1	94.6	92.8	91.5
72	1743	2	92.6	95.7	92.3
72	1743	3	100.0	100.0	96.3
93	2206	0	97.6	95.4	92.3
93	2206	1	97.9	95.8	93.6
93	2206	2	100.0	100.0	94.6
93	2206	3	95.0	93.2	91.8

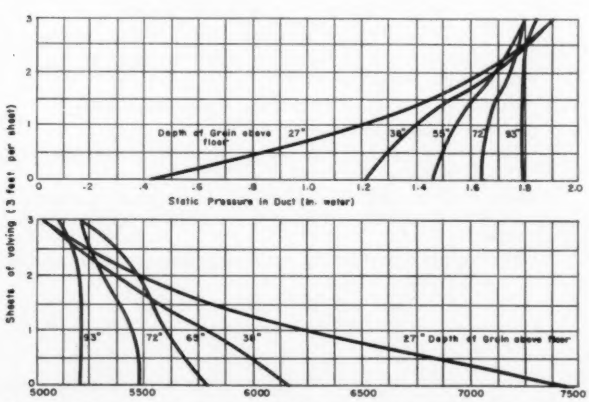

Fig. 1 Effect of valving on total air flow and static pressure for various depths of wheat in a quonset

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Acknowledgments: Equipment and grain transportation costs furnished by Stran-Steel Corp., Ecorse, Mich. Wheat was furnished by C. J. Carruthers, Bancroft, Mich.

*Number in parentheses refer to the appended reference.

procedure was repeated for each two additional loads of wheat until the bin was full.

From the static pressures measured, equal static-pressure lines spaced at 0.1 in of water were drawn on scale diagrams of the bin cross section. A scale of 1 in equals 10 in was used to facilitate computations.

A relationship was set up between air flow in cfm per sq ft and distance between pressure lines spaced at 0.1 in of water. The data were obtained from "Resistance of Grains and Seeds to Air Flow" by C. K. Shedd, AGRICULTURAL ENGINEERING, September 1953, for wheat at 11 percent moisture content. The above relationship plotted nearly as a straight line on logarithmic paper (1).* From these data, a relationship between air flow in cfm per bu and distance between pressure lines was obtained.

Results

The effect of valving on static pressure and total air flow is shown in Fig. 1. It is evident that at shallow depths of grain a small amount of valving decreases the air flow considerably while at greater depths, the valving has a reduced or no effect on the total air flow.

To obtain a more detailed evaluation of the effect of valving, the air-flow rates throughout the building were analyzed. Michigan recommendations call for 3 to 5 cfm per bu for wheat; therefore, values of 3, 4 and 5 cfm per bu were used as criteria for analysis. Cross-sectional areas were obtained with a planimeter. The results are expressed as percentage of wheat receiving more than 3, 4 and 5 cfm per bu as shown in Table 1. A value of 100 percent indicates adequate air flow throughout the bin for the ventilation rate considered.

At shallow depths a small amount of valving is significant in reducing areas receiving inadequate ventilation, but at deeper depths the effect was not as great. Although data were not obtained for more than three sheets of valving at depths less than 3 ft, by extrapolation of data in Table 1, it appears that five sheets (172-in wide) should be used.

For shallow depths grain directly over the duct could be dried before the valving is placed over it.

Conclusions

1 By extrapolation of data, five sheets of valving (172-in wide) will be required to give maximum uniformity of air flow for depths of grain less than 3 ft in a building 16 ft wide.

2 Three sheets of valving (104 in wide) are necessary for maximum uniformity of air flow for depths ranging from 3 to 6 ft of grain.

3 Two sheets of valving (70 in wide) will give maximum uniformity of air flow for depths of from 6 to 8 ft of grain.

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Attachments for Combining Corn

(Continued from page 800)

sickle left much to be desired in the cutting of large, tough cornstalks.

The next move was to develop a one-row force-feed gathering mechanism, which was assisted by a raddle conveyor underneath to replace the canvas carrier to the cylinder. This unit was more satisfactory, but there are some difficult problems in the complete processing of stalks 12 ft or more in height, of large diameter, and in some cases down and tangled.

During this period of development, we found little interest in the saving of residues. Since it took power to process the stalk in order to harvest these residues, it was quite natural to save this power and to think toward the development of a two-row snapping and shelling attachment. By the use of special snapping rolls and stripper plates, it was possible to cut the shelling loss to a minimum. The gathering mechanism, coupled with an elevator to the cylinder for each row, permitted operation in practically any condition of corn and with speeds up to 5 mph, depending on conditions.

The attachment could be installed on the standard grain harvester and permitted a wide range of adjustment for row spacing. A distributing auger behind the elevators and in front of the cylinder spread the corn over the full width of the cylinder, and, in general, arranged the ears to come in contact with the cylinder with the length of ear parallel to the cylinder bars.

It was found that the angle-bar cylinder did an excellent job of shelling but that its use must be understood. We used eight bars on the 15 in cylinder with channels in between to keep the ear corn from dropping through. The resistance members or concaves were 7/16-in round rods, and the cylinder clearance was set about ¾ in. The ears would roll until they were stripped of corn, and then the cobs would pass through the machine. Normally, the cylinder speed should be about 800 rpm with 15-in diameter and very little crackage would result.

The separating and cleaning mechanisms normally designed for grain have liberal dimensions and will deliver clean corn to the storage tank. We have seen the machine handle up to 6 bu of corn per minute with extremely low losses both at the snapping rolls and through the machine.

As we see it, a successful field corn-shelling attachment and machine combination should incorporate the following features:

- It should be low in cost.
- It should be easy to install.
- It should be easy to adjust for different row spacings.
- It should have plenty of lift for ground clearance.
- It should handle large and small stalks, green or dry stalks, and take them standing or down and tangled.
- It should have plenty of shelling capacity without cracking.
- The machine should have good cleaning capacity.
- It must be strong enough to take rough service.
- It must have plenty of capacity to handle heavy yields.
- The machine must be maneuverable.
- The power requirements of a two-row, pulled-type unit should be within the range of a 2-plow tractor.
- The machine must have plenty of storage-tank capacity because of the number of bushels per minute delivered to the tank.
- The machine must be equipped with plenty of tire capacity for bad going.
- The unit should unload while traveling.
- There should be an improvement in the losses normally incurred by a picker.

If the attachment and machine are to be successful generally, adequate drying equipment will have to be made available, except for the wet milling industry.

Evaluation of Dust Deposits by Polarography

N. T. Ban and W. M. Carleton
Member ASAE

IN DUSTING or spraying work, biological evaluation is slow and not always desirable because of the uncertainty of infestation. In order that investigations can be carried out effectively and with dispatch, many workers have resorted to physical or chemical evaluation methods. The chemical evaluation approach seems to be prevalent (leaf printing, titration . . .), but the methods in use, although accurate, require a large expenditure of time to perform the actual evaluation. On the basis of work to date the authors believe that the polarographic method of evaluation, applied to dusts* and sprays will help to cut down the time normally required for evaluation and be at least as accurate as other methods in use.

Laboratory results presage polarography to be a fast and accurate method of evaluating deposit efficiency of organic or inorganic dusting and spraying materials—even in the field

Definition of Polarography

The polarographic method of chemical analysis is based on the interpretation of the current-voltage curve obtained from the electrolysis of electroreducible or electrooxidizable substances in a cell at a dropping mercury electrode (or a rotated platinum microelectrode). This electrode is small and easily polarizable while the other electrode of the cell is large and non-polarizable. For simplicity and clarity the ensuing development is for electroreducible substances only. Consideration of the latter will avoid repetition of the two terms "electroreducible" and "electrooxidizable."

The fundamental differences between the polarographic method and the electrolytic method may be tabulated as follows:

Parameters	Method: Polarographic	Electrolytic
Electrodes	Cathode: Dropping mercury electrode or rotated microelectrode Anode: Mercury pool or saturated calomel electrode	Cathode and Anode· Platinum or mercury electrode
Variables measured	Currents measured with increasing applied emf	Current or voltage constant
Concentration range	Low limit 10^{-6}M	All concentrations
Depletion of electroreducible substance	Practically unaltered	Complete
Duration	Short, usually a few minutes	Until completion of electrochemical reaction

Polarograph

The electrical circuit used is similar to the one for electrolysis, a schematic diagram of which is shown in Fig. 1. For electroreduction an increasing negative electromotive force (emf) is applied between the electrodes by varying the resistance *(R)*. The current for each applied emf is measured with a galvanometer *(G)*. The plot of current against voltage results in a polarogram (Fig. 2).

Polarogram

The limiting current *(i)* is the total steady current measured (Fig. 2). The limiting current is reached when the re-

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Acknowledgment: The authors wish to acknowledge generous technical advice of Andrew Timnick, department of chemistry, Michigan State University, during this project.

*By dust is meant agricultural dusts used as fungicides and insecticides.

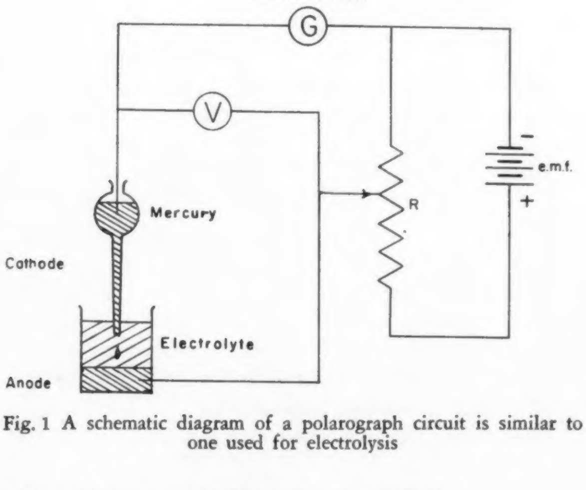

Fig. 1 A schematic diagram of a polarograph circuit is similar to one used for electrolysis

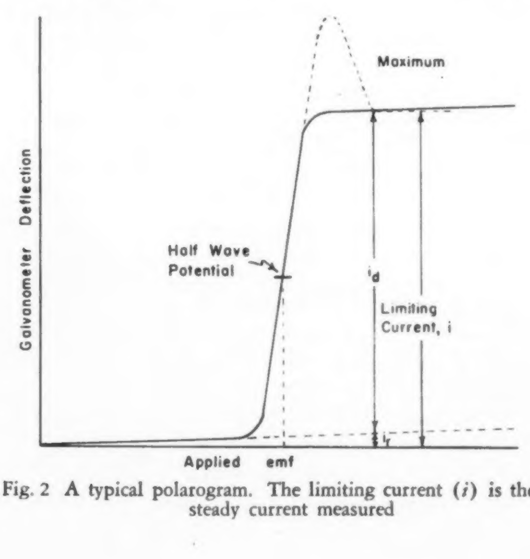

Fig. 2 A typical polarogram. The limiting current (*i*) is the total steady current measured

ducible substance is reduced as rapidly as it reaches the electrode surface, and its concentration at the electrode surface remains constant at a value that is negligibly small compared to the concentration in the body of the solution. Under these conditions, the current is independent, within certain limits, of the applied emf and is governed wholly by the rate of supply of the reducible substance to the electrode surface from the surrounding solution.

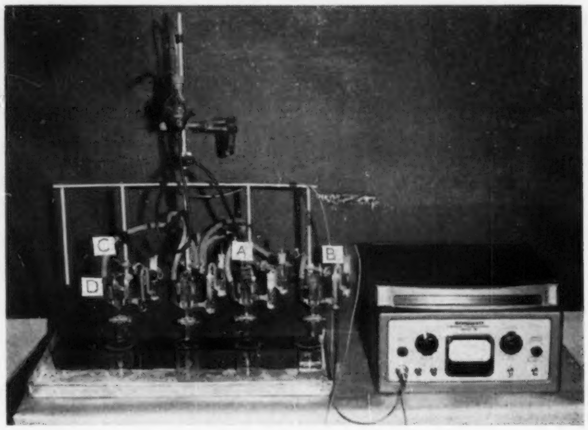

Fig. 3 The polarograph assembly: (A) dropping-mercury electrode (cathode), (B) saturated calomel electrode (anode), (C) nitrogen inlet, and (D) H-type cell

Of the many factors influencing this current, four main ones are:

1 The residual current (i_r), usually very small and approximately proportional to the applied voltage, caused by traces of the electro-reducible impurities.

2 The "maximum," a transitory and erratic current, the origin of which is not completely understood. However, it is eliminated by the introduction of a surface-active material or charged colloids, *e.g.*, gelatin.

3 The migration current due to charged particles in the electric field. It is eliminated by the addition of an indifferent or supporting electrolyte in a concentration of at least tenfold that of the reacting material.

4 **The diffusion current (i_d) which indicates the concentration of the material being reduced.**

$$i_d = i - i_r$$

The diffusion current depends on temperature, viscosity, the ionic strength of the solution, and the characteristics of the polarizable electrode. The influence of these factors can be seen in the Ilkovic equation, derived for the dropping mercury electrode for constant temperature:

$$i_d = 607\ n\ D^{1/2}\ C\ m^{2/3}\ t^{1/6}$$

where i_d is the average current in microamperes during the life of a drop of mercury, n the number of faradays, D the diffusion coefficient of the reducible or oxidizable substance in square centimeters per second, C its concentration in terms of millimoles per liter, m the rate of flow of mercury from the dropping electrode capillary in milligrams per second, and t the drop time in seconds (3)†.

This equation predicts a linear relation between the diffusion current and concentration which is the most important relation in practical polarography.

The half-wave potential is characteristic of an electroreducible substance in a known supporting electrolyte, and serves as the basis for qualitative identification of the substance.

Quantitative polarography is based on the complete concentration polarization or the depletion of the concentration of the electro-reducible substance at the electrode surface by the electrode reaction which results in a limiting current over a range of potential.

Apparatus

A Sargent Model III polarograph was used in conjunction with a saturated calomel electrode and an H-type cell. The cathode was of the dropping-mercury-electrode type, with the drop rate adjusted to 3 sec per drop.

Application

Practical polarography as applied to dust evaluation does not require the complete plotting of the polarogram for routine ananlysis. During the evaluation only the concentration of the reduced substance is measured, it being the only variable in the Ilkovic equation while the other factors are held constant.

Hydrated copper sulfate ($CuSO_4 \cdot 5H_2O$) was selected as a dusting material to be used both for the laboratory and the field tests, because of its solubility in water and because copper is a common element in dusting or spraying materials.

†Numbers in parentheses refer to the appended references.

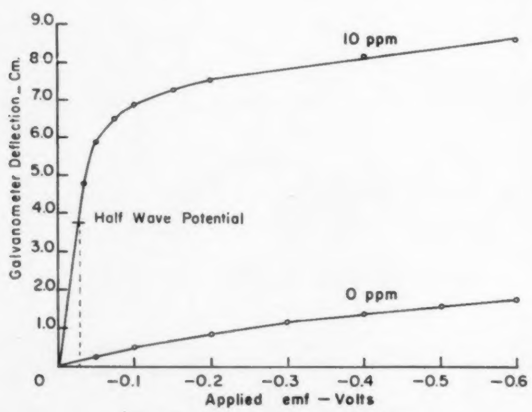

Fig. 4 Polarogram of copper sulfate

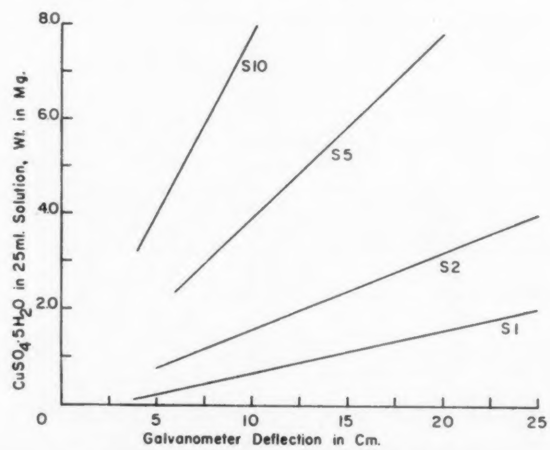

Fig. 5 Calibration curve for copper sulfate

The polarographic evaluation involved essentially two parts:

- The construction of a calibration curve
- The actual evaluation.

Calibration

A standard solution of $CuSO_4 \cdot 5H_2O$ was prepared in the laboratory, and various known concentrations were obtained from this standard solution by dilution.

To eliminate the effect of the migration current, 0.4 N potassium sulfate solution was used as the supporting electrolyte. Gelatin at a concentration of 0.01 percent was used as the "maximum" suppressor. Approximately 20 ml of the solution was introduced in the H-type cell (Fig. 3), and nitrogen was bubbled through for ten minutes or more to remove atmospheric oxygen before the analysis.

A 25-ml standard solution containing 10 parts per million of copper was run and its polarogram was plotted (Fig. 4.) This plotting is a preliminary step to determine the half-wave potential of copper in 0.4 N potassium sulfate solution, and also to find the potential at which the limiting current becomes steady. From this polarogram, the value −0.4 v was selected as the applied emf for routine analysis.

Subsequent standard concentrations were then analyzed by bringing the applied emf immediately to −0.4 v and recording the galvanometer deflection. A calibration curve was constructed from these data (Fig. 5) Instead of plotting galvanometer deflection as a function of concentration, the weight of hydrated copper sulfate was computed from the concentration and plotted as a function of the galvanometer deflection. In this way, one reading of the calibration chart gives the amount of hydrated copper sulfate in 25 ml solution.

Actual Evaluation

The dust deposits on leaves were washed in 25 ml of 0.4 N potassium sulfate solution. These solutions were then brought to the laboratory where the evaluation was carried out. The following steps were then taken during the routine analysis:

1 Gelatin was added to the solution to a concentration of 0.01 percent.

2 About 20 ml of the solution was introduced into the H-type cell.

3 Nitrogen was bubbled through for almost 10 min.

4 An emf of −0.4 v was applied and the galvanometer deflection recorded.

5 The emf was brought to zero and the galvanometer deflection recorded. This value was subtracted from the reading obtained in step 4, and the resulting value used to find the amount of hydrated copper sulfate in solution from the calibration chart.

Discussion of Results

Copper concentration as low as 1 ppm was readily measured. Concentration of this magnitude was obtained in dusting tests on soybeans, at a rate of 30 lb per acre, and from a leaf surface area of 10 sq in (dust from both sides). Detection at this low concentration with this method reduces greatly the necessary quantity of leaves collected per sample.

With care, the measurement of the reduced material concentration can be as low as 10^{-5}M (molar concentration or moles per liter). The time required to run one individual sample is 15 min or more, but with the multiple cells method devised for the tests (Fig. 3), the time requirement was reduced to 6 min per sample. It should also be pointed out that, although this method of analysis is chemical in nature, it requires far less chemical manipulations than other chemical methods.

Scope of the Polarograph

The polarographic method of dust evaluation is not restricted to copper measurement alone. The method can be applied to any other dusting materials, organic or inorganic, provided that a suitable solvent and a good supporting electrolyte are found for each one, and provided that the substances measured are electroreducible or electrooxidizable. (A bibliography of polarographic literature between 1922-1945 is listed in reference 4.)

Although the evaluation was carried out entirely in the laboratory, this method could be adapted readily for field work. The whole setup can be mounted easily in the back of a pickup truck.

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Rice Hull Bricks Absorb Atomic Radiation

AN agricultural engineer, J. H. Hough, assistant professor at Louisiana State University, has developed a lightweight, low-cost brick for use in the construction of farm buildings by utilizing burned rice hulls.

The development may be one of the answers for practical use of some 90,000 tons of rice hulls which are dumped as waste each year in Louisiana. Perhaps even more significant is the brick's apparent ability to absorb atomic radiation and provide possible protection against atomic fallout.

The key to the development is said to be a chemical change in the rice hulls when burned. Being organic, the hulls turn into a mineral state which is 94.5 percent silica. The ash flakes are porous and contain numerous non-connecting cells which make the material a good insulator.

The soilash bricks, so named because they are made of equal parts of ash and soil and some emulsified asphalt, could be made by the farmer at an estimated cost of five cents each. Water is added to the mixture to form a plastic mass, similar to mortar in consistency. The mass is poured into forms and the bricks dried in the shade for about a week before being exposed to the sun for curing. The new bricks were subjected to three severe tests. A 144-hr needle water spray had no effect on their surafce. They passed alternate freezing and rapid thawing tests and resisted water soaking.

How Research and Development Aid Machinery Design

Edward A. Silver
Member ASAE

Why research and development are figured in on the budget of farm equipment manufacturers can be deduced from the following account of their importance in machinery design

THE problem of creating values in new or improved machines for agriculture is a complex one. In fact, many problems are encountered between the inception of an idea and production of an accepted and useful machine. It is here that research and development can shoulder a responsibility by uncovering, evaluating, and assembling the facts on which to base useful and needed designs.

Before the role that research and development play in design can be discussed intelligently, it is imperative and advisable to have a perspective of the various agencies directly affected by and contributing to new developments.

Technology in agriculture is advancing at a rapid rate. Industry, therefore, must be capable of detecting and evaluating the real needs for equipment to satisfy changing demands. Economically, production costs must be held at a minimum and sales must be kept up. An obsolescent machine can become a serious problem for the manufacturer.

Equipment must be designed to perform its function when optimum conditions exist. Agricultural machines depend on each other in the complete farming process from tilling to harvesting, and a deficiency in one operation reflects in the total crop yield.

An important factor, often not understood by many, is that a farm machine designed to perform a specific job should be in great enough demand to justify its inception and production on a profitable basis.

Few pieces of equipment, or machines, are subjected to greater destructive forces than are faced by farm equipment. It is exposed to all kinds of climatic conditions and is operated in a multitude of soil and terrain variations. These and many other factors must be considered in the manufacture of a farm machine.

Design of a farm machine does not start on the drafting board; it starts in the field where the idea was conceived. There its true function is determined. However, before the final design can be completed, the forces and sizes of the complete unit must be determined. Seldom is a machine completed in one design. Short seasons limit experimentation, and the number of machines developed from the prototype model to the final production run may be many.

Research and development are among the fastest growing functions in American industry today. They play a vital role in the development of new products, new processes, and new methods. Authorities have estimated that 85 percent of the business volume today is built upon products that were unknown 10 years ago.

The author—Edward A. Silver—is research engineer, New Holland Machine Division of Sperry Rand Corp.

Paper presented at the North Atlantic Section meeting of the American Society of Agricultural Engineers, University of Vermont, Burlington, August 1954.

Acknowledgment: The paper was prepared in cooperation with A. M. Best and G. K. McCutcheon, engineers, Research and Development Section, New Holland Machine Division of Sperry Rand Corp.

Research primarily is a thought process, intelligently controlled and directed for coordinated action. In fact, it is reflective thinking, by which an idea unfolds step by step—the same as one reads a book by starting at the first page and reading forward to the end.

C. F. Kettering, of research fame, expresses it thus: "Research is not something you do in the laboratory; it is a state of mind." Henry P. Kendall of the Kendall Company defined it as " a department of a business which carries the responsibility of uncovering new facts of nature and the interpretation of these facts into utility so that management can provide improved, more economically priced products, and, above all, new products to meet unexpressed human desires."

Research with proper balance is creative. It embodies considerable risk, but risk of the calculated type is an inherent element of progress. Research must be alert and competent to detect problems of far-reaching importance and to clarify the fact basis for clear thinking and right action.

Development is the application of results proven by research; it converts them into end items. These may not necessarily be finished products from the standpoint of final design. The trial machine may consist of a single prototype model with a logical grouping of functional units. In development work, objectives become more clearly defined, where a definite product is in mind.

Coordination of research and development is paramount to aid in design. Welding individuals into team efforts to attack problems with combined knowledge is imperative. Some authorities feel that other branches of the industry, such as manufacturing and sales, should be brought into the picture early, in order to familiarize them with any problems and to supplement thinking along the course of development.

Methods and procedures for conducting research have undergone radical changes during the past 10 to 15 years. Integration of research techniques toward a common objective is important and necessary, if the contribution to the end result—design—is to be fully realized.

W. H. Kliever, vice-president and director of instrument development, Clevite-Brush Development Co., has said, "Research efforts directed into wrong channels, or worse yet, not directed at proper objectives, can waste money faster than almost anything else a company can do."

Many steps are involved from the inception of an idea to the finished product. Needless to say, the shortest distance between two points is a straight line. From this analogy, it can be assumed that the path from the idea to the final

objective should be as direct as possible. This will avoid costly delays and pitfalls. An omission is an open door to trouble, and any abrupt halt to a program is costly.

Ideas should be screened thoroughly by competent personnel and decisions made as to whether or not active investigation can be justified. The objective of the project must include all facts, pro and con, on the proposed development. Arguments from literature, files and experience also should be included. A system can be set up by which a development, throughout its course, can be evaluated, discontinued, or carried to a conclusion.

Perspective is important in planning programs. It is desirable to have some sort of balance between short-range and long-range developments. The short-range types are of the bread-and-butter variety, while the long-range types provide future stability.

Research in the agricultural equipment industry is largely within two areas: (1) the area of discovery and interpretation and (2) the area of application. The first involves the discovery and evaluation of facts, principles, elements, or methods. It is here that basic research plays its part. The second molds these findings into practical applications—the function known as development.

In the manufacture of farm equipment, most of the basic research is done by scientists at state and federal experiment stations. However, industry must accept a great responsibility for the true interpretations of these discoveries as a basis for machine designs. That is rightfully basic research.

It is unwise for industry in many cases to wait until final results have been achieved by the experiment stations on projects of a basic nature. More will be accomplished if industry proceeds on a parallel basis during the course of the investigations by checking and evaluating with the scientists and engineers doing the work. If the problem involves mechanization as an end result, both agencies reap a benefit from this cooperation, and possibilities have been enhanced for a more complete and better solution to the problem.

It has been said that all engineers should engage in research of one form or another. Blocking of ideas from anyone, or any attempt to stifle thinking, should never be tolerated; however, if anyone is held responsible for all research endeavor, then it becomes unorganized research at its worst.

The search for new ideas usually takes on the form of a race, because competitors are following the same practice. Thus it becomes important to consider all ideas, regardless of their source, in order to form a stock pile of knowledge for possible utilization in the future. It is extremely important that these be screened carefully and evaluated before acceptance.

The detection of a need for any farm machine or tool is the most basic factor to its adoption. It is the first step to design procedure. Without the discovery of this fact, there would be little incentive to proceed further. If a machine is produced on the basis of a need, barriers to sales are reduced greatly.

Detecting a need for a farm machine or any unit of a machine to meet proven agricultural practices is not as simple as it may seem. It requires natural vision, keen observation, eager curiosity and ability to recognize a problem. Of equal importance is the ability to differentiate essentials from non-essentials. The problem must be analyzed thoroughly and a technique developed to determine the need.

Probably the most important sources of information to support a need lies in the scientific findings of state and federal experiment stations. However, many facts of real significance have come from farmers, engineers, field men, and others in allied fields. Aid also comes through publications, such as reviews, abstracts, summaries and indices.

A need does not always give reason to manufacture a complete new machine. It can account for a new principle within a machine. Occasionally, a machine is developed and is defined as a freak. The reason for this is that the problem or situation on the farm has not been analyzed properly on the basis of its true function. It has not fullfilled some of the four "musts" of a new development: (1) do a better job at the same cost, (2) do the same job at a lower cost, (3) do a job no other machine can do, or (4) effect substantial savings which justify the customer's purchase.

A farm machine is composed of one or more functional units. The sum total comprise the very heart of the machine. Their operation and efficiency determines largely whether or not the machine will perform to the user's satisfaction and the manufacturer's expectations. Here again, research and development, closely integrated, can set a pattern to aid in design.

Once the need for a machine has been definitely proven, the next logical step is to arrive at the type, number, and integration of the functional units. To approach this problem effectively, the requirements of the machine must be worked out carefully in detail. The job to be done should be analyzed and a type of functional unit adopted to perform a given job best. Here research can well accept a responsibility of great importance by carefully outlining these functions for the subsequent development phases of the problem. The number of functional units should be held to a minimum without losing efficiency of the total machine, and all units should be integrated carefully to permit direct and uninterrupted flow of materials through the machine.

Determination of the functional performance of the various units is of extreme importance to subsequent design. This is particularly true on machines having new principles and a complexity of units. Furthermore, it is desirable to prove these one at a time before combining them into the whole machine. Some may consider this procedure wasteful of time. The close relationship of all units, the dependence one to the other in over-all performance, demands this approach.

There are great opportunities for improving functional units on present machines. Much has been accomplished, yet much can be done. Moreover, it is dangerous to keep the market supplied only with old products tinged with obsolescence. Competition in many ways is a stimulating agent in bringing about changes. Industry is usually known by the fitness of the products it sells and the only way for industry to progress is through change in products to meet the ever-increasing demand of agricultural technology.

Research and development can play an important role in aiding design of farm equipment to better fulfill the needs and welfare of the farmer, and to maintain financial

(Continued on page 812)

Effects of Electromagnetic Energy on Plants and Animals

Vernon H. Baker, Dennis E. Wiant and Oscar Taboada
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Studies reveal a definite relationship between radiant-energy wavelength and the degree and nature of tissue damage when electromagnetic radiation reacts with a biological material. Among topics discussed are the quantum theory, the electromagnetic spectrum, the division of the spectrum into heating and ionizing radiation and the effects of radiation on living cells

THIS paper reports the results of part of the analyses and experiments on the effects of electromagnetic energy on biological material, including insects.* Other related papers have been presented.†

Scientists working with living things are becoming more and more aware that there are definite relationships between electromagnetic energy and life. Investigators who work with plants and animals have realized the need for grouping basic physical laws which relate to the effects of electromagnetic energy on biological material.

The purpose of this paper is to assemble and discuss some of the important basic laws involved when electromagnetic energy reacts with matter. Topics discussed include: the electromagnetic spectrum, electromagnetic waves, and method of generation; the quantum theory and black body radiation; dividing the spectrum into heating and ionization areas; transmission and propagation; absorption of ionizing radiation; effects of heat on living cells, and effects of ionizing radiation on living cells.

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*Baker, V. H. Some effects of electromagnetic energy and subatomic particles on insects which infest wheat, flour, and beans, unpublished Ph.D thesis—Michigan State University, 1953.

†Baker, V. H., Oscar Taboada and D. E. Wiant. Lethal effects of electrons on insects infesting wheat and flour, Agricultural Engineering Part I, November 1953; Part II, June 1954.

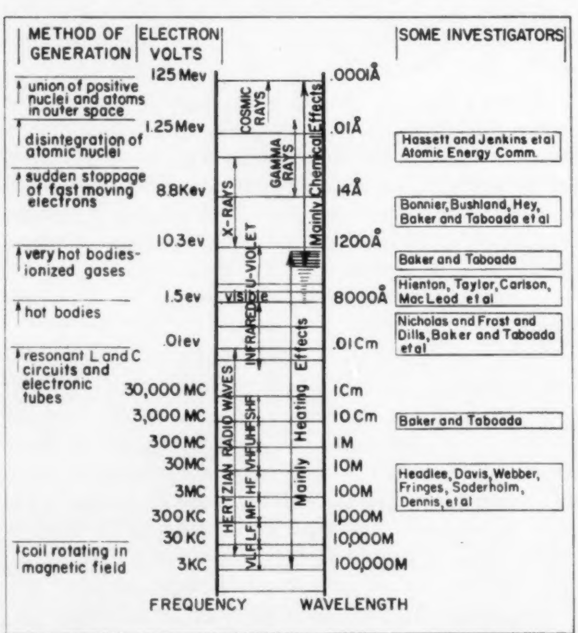

Fig. 1 The electromagnetic spectrum with method of generation and a partial list of investigators of the lethal effects on certain insects

The Electromagnetic Spectrum

Classical theory in physics points out that all electromagnetic waves are similar, differing only in frequency or wave length, regardless of the method of generation. Thus the frequency or wave length distinguishes one area of the spectrum from another. However, the method of generation has been used to refer to certain areas of the spectrum. A sketch of the spectrum, Fig. 1, lists the wave length, frequency, and method of generation of the various areas of the spectrum. Frequencies above about 30,000 million cycles are not listed since it is more common to refer to this part of the spectrum in terms of energy in electron volts.

Electromagnetic Waves. Electromagnetic wave theory is complex. An electromagnetic wave is considered to consist of a component of an electrical field and a component of a magnetic field. A field is defined as a region in which a particular kind of force is exerted. These two components, in a polarized wave in free space, are at right angles to each other in a plane perpendicular to the direction of travel, and the energy is divided between the magnetic-field component and the electric-field component.

The electric field with component lines of force is considered to begin on a plus charge and end on a minus charge. These lines of force or flux do not form a closed loop. An electrostatic field can be only static. The electric field generally may be referred to as static or dynamic. The divergence of the electrostatic induction of any point in a medium is equal to the charge density of that point. In particular, at points in a medium where the charge density is zero, the divergence of the electrostatic induction is zero(1)‡.

Since free magnetic poles do not exist, then all lines of force in a magnetic field are continuous; i.e., they form a complete loop, and the divergence of magnetic induction is zero.

An electromagnetic wave thus contains a component of electric lines of force, and a component of magnetic lines of force which form a closed loop, and the varying electric field produces a changing magnetic field. Each component vibrates with the same frequency, and in free space the two components are in phase. The two components are at right

‡Numbers in parentheses refer to the appended references.

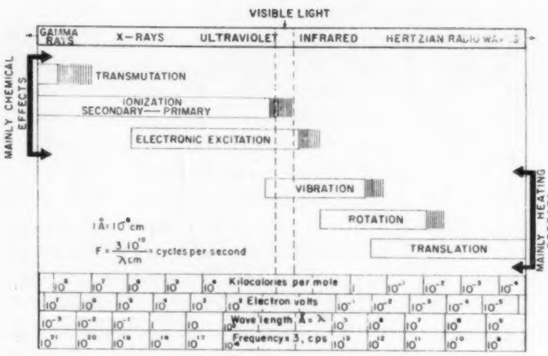

Fig 2 The primary processes of the reaction of electromagnetic energy with matter (adapted from a chart released by Brookhaven National Laboratory under contract with the U.S. Atomic Energy Commission)

angles to each other and are perpendicular to the direction of propagation.

Method of Generating Electromagnetic Energy. The various methods of generating electromagnetic energy are shown at the left in Fig. 1. The processes involved when electromagnetic energy reacts with matter are shown in Fig. 2. Somewhat the same processes occur when electromagnetic energy is generated; i.e., electronic or atomic translation, rotation, vibration; electronic excitation; ionization and transmutation.

Electromagnetic energy for the low frequencies up to about 3 kc (kilocycles) may be generated by rotating a coil in a magnetic field, and frequencies above this value, up through Hertzian radio waves and including part of the infrared spectrum, may be generated by the use of resonant circuits containing inductance *(L)*, capacitance *(C)* and electronic tubes. The processes involved in generating the lower frequencies, VHF and UHF, are electronic translation and rotation, whereas for most of the infrared spectrum atomic and molecular vibration and rotation are involved (Fig. 2). Infrared, visible, and ultraviolet energy can be obtained from some heated body, from a gaseous discharge tube, or from arcs.

Infrared radiation involves the displacement of atoms in the molecule and is due to the rotations and vibrations of atoms. These displacements are caused by heat in a heated body and all solids give about the same distribution or radiation among the different wave lengths at a given temperature (2). Radiation in the ultraviolet and visible spectrum is due to displacement of outer electrons in atoms or molecules and the return of these displaced electrons to their lower states (3). X rays have a similar cause except that the displacement of inner electrons close to the nucleus of the atoms are involved. Gamma rays are emitted from excited nuclei of various atoms (3). Gamma rays have the same properties as X rays. Radiation associated with cosmic rays, which reach the earth from interstellar space, will not be discussed here.

The Quantum Theory

Maxwell's equations are adequate to explain most phenomena in the portion of the spectrum up to and including part of the visible. However, in order to explain fully the characteristics of the spectrum with a frequency above microwaves, quantum theory (5) is required. According to this theory, radiation is not a smooth flow of energy but a series of pulses of energy. The energy in each pulse increases with the frequency of the electromagnetic wave. The quantum concept is a theory that in the emission or absorption of energy by atoms or molecules the process is not continuous, but takes place by steps. Each step is the emission or absorption of a quantum of energy called the photon. Photons are considered to have the properties of moving particles. This energy may be represented by

$$Ve = E - h\nu = hc/\lambda \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [1]$$

where V = volts

e = charge on electron = 4.8×10^{-10} esu (electrostatic units)

E = the energy of the photon in ergs

h = Planck's constant, a fundamental constant of nature = 6.62×10^{-27} erg-sec

c = the velocity of light 3×10^{10} cm per sec

ν = the frequency of the radiation in cycles per sec

λ = the wave length of the radiation in centimeters.

Transmission and Propagation of Electromagnetic Energy

Electromagnetic waves will travel through a vacuum. Their passage through matter is accompanied by some loss of energy. This absorption of electromagnetic energy by matter will be discussed in another section of this paper.

Polarization of Electromagnetic Waves. The electromagnetic waves similar to the radiated waves of most commercial broadcasting stations, are polarized with the electric field in the vertical plane and the magnetic field in the horizontal plane.

In light waves each atom or molecule acts individually in creating a light wave, resulting in radiation of a random nature; i.e., ordinary light, a form of electromagnetic energy, consisting of many separate components each polarized at some arbitrary angle. Thus, the over-all effect of such combinations shows none of the properties of a polarized wave; however, by the use of filters, the unpolarized components may be removed.

Dividing Spectrum into Areas of Heating and Ionization

From equation [1] the wave length of the energy necessary to ionize a given element or compound may be calculated:

$$\lambda = \frac{hc}{eV} = \frac{(6.62 \times 10^{-27})\,(3 \times 10^{10})}{(4.774 \times 10^{-10})\,(V/300)\S} = \frac{12.407 \times 10^{-8}}{V}\,\text{cm} = \frac{12{,}407}{V}\,\text{angstroms}\,(A)$$

The wave length of radiation necessary to ionize a given element can be calculated from this equation by inserting the ionization potentials for that element.

The ionization potentials for free atoms of the major elements that are likely to be in biological tissue are given in reference 7. The lowest ionization voltage in this table is 4.32 v for the outermost electron and 46.5 v for the innermost electron of potassium.

From equation [1] $\lambda = \dfrac{12{,}407A}{V}$

§1 statvolt.

The range of wave length necessary to ionize potassium for the outermost and innermost electron respectively using equation [1] are $\lambda = 2880\ A$ and $\lambda = 268\ A$.

Other ionizations will take place up to very high energies.

By referring to Fig. 1, it is seen that the λ's for potassium lie in or about the ultraviolet spectrum. All other ionization λ's for the elements likely to be found in tissue would probably be less than 2880 *A* since the remaining ionization potentials (7) are greater than the 4.32 v, or the ionization potential for the outermost electron of potassium.

From this analysis it would seem logical to conclude that the part of the spectrum with wave lengths less than about 2880 *A* would contain more than enough energy in a photon to ionize the major elements found in tissue. It is on this basis that the line on Fig. 1 is drawn between heating effect and ionization effect. The 2880 *A* area may be taken as an approximate dividing line between the heating and ionization. Actually there are other effects; processes such as photosynthesis and the reaction of visible and infrared energy with photographic film may be classified as chemical effects.

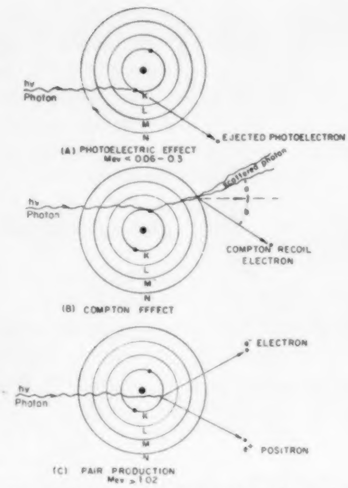

Fig. 3 Mechanism by which far-ultraviolet, X rays, and gamma rays are absorbed by matter. Processes occurring when photons strike an atom are illustrated

To apply this analysis to living organisms, we make the hypothesis that ionization of any of the compounds of the elements would be lethal to the living cell. If the potentials necessary to break off certain bonds or ions from chitin, proteins, lipids, and atoms of other complex compounds in living organisms were known, the ionization frequency could be calculated. There is insufficient information on bond energies at this time to make such calculations, so the analysis for free atoms is presented. Bond breakage in molecules will cause chemical changes and perhaps at considerable lower energies.

Effects of High Temperatures on Living Cells. Rahn (8) has presented a report on the effects of temperature on life. The rate of the lethal effect of heat depends on the temperature and time of exposure. Practically all cells live within a narrow range of temperature between the freezing point of water and 107 F. Life as we know it is not permanently possible outside this range of temperature.

The laws of thermodynamics can be applied to the living organism with one exception. This exception is that no mathematical or physical laws have been able to predict the effects on "extra-sensory perception" in the living organism. Some biologists have developed empirical equations in an effort to tie in this effect with physical laws.

Generally, temperature affects chemical reactions. The reaction rate changes with temperature and practically all reactions show an increase in rate with an increase in temperature.

The proteins in the protoplasm of living cells are coagulated by heat. The coagulation in heat-killed cells is plainly visible under a microscope. If a protein whose function is necessary for cell life coagulates completely, the cell dies. Not all of the many proteins in any one cell have the same coagulation temperature. The over-all affect is a matter of rate of coagulation. If the coagulation takes place slowly the living cell can produce new enzymes and oxidase, and repair the damage. As long as the rate of repair keeps up with the rate of inactivation, the cell will continue to live. When the rate of repair is equal to the rate of destruction, the cell is said to be at the *optimal temperature,* or the temperature of greatest life activity. As the cell temperature increases above this point, a lethal temperature will eventually be reached where the destruction rate is increased considerably and where the repair rate is practically negligible. When the cell temperature is increased above the lethal temperature, cell catalysts will be destroyed and the cell will die.

The death rate of single-cell animals due to lethal temperature generally follows the so-called "logarithmic order of death". This does not apply to multicellular animals including insects. Individual insects normally show no body temperature increase of their own, because they give off surplus energy of respiration; however, in large masses their body heat accumulates.

The analysis in an earlier section of this report leads one to believe that the lethal effect of radio-frequency dielectric heating, microwave, infrared, and most of ultraviolet radiation can be only a temperature effect.

Absorption of Ioninzing Radiation by Biological Tissue

Much of the early work on the biological effects of radiation has been summarized by Duggar (9). Every quantum of ionizing electromagnetic energy absorbed by biological tissue can affect at most only one primary absorbing atom (10). The secondary product from an absorbed quantum, usually a dislodged electron, will then be set free to strike other atoms and thus form ions. Then most of the effects on living tissue of ionizing radiation, whether it be an electromagnetic quantum or an incident subatomic particle, are due to ionizing particles. The three mechanisms by which electromagnetic energy is absorbed are shown in Fig. 3. These processes are the photoelectric effect, Compton effect, and pair production (3).

These processes can occur when there is energy enough, and for pair production there will not be energy enough except in the gamma range, unless one includes mev (million electron volts) X rays. These same processes do not occur when subatomic particles are used except after the subatomic particles have radiated by interaction with other particles.

The photoelectric effect Fig. 3A obeys Einstein's photoelectric equation, $hv = \phi + \frac{1}{2}mv^2$, where hv represents the total energy of the incident photon, ϕ the energy required to remove the electron from its atom, and $\frac{1}{2}mv^2$ represents the kinetic energy of the ejected electron. These ejected electrons may have enough energy to cause ionization in nearby atoms.

The Compton effect is represented in Fig. 3B. This process is dominant for photons with energies as low as 100 kw (kiloelectron volts). Fig. 4B illustrates that when a photon of energy in the X ray or gamma region strikes an electron

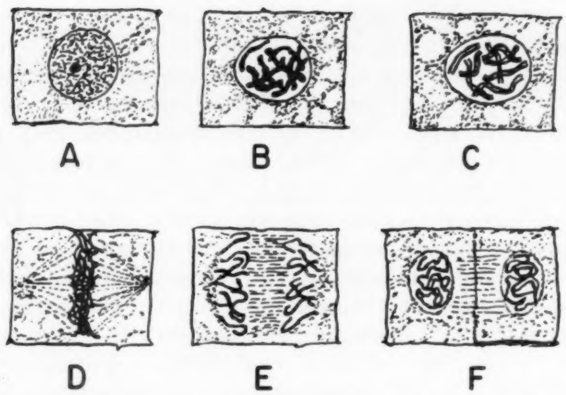

Fig. 4 Sketch illustrating plant cell division. *A*, Resting cell, the chromatin of the nucleus in a fine network; *B*, the chromatin is gathered into chromosomes and assumes definite number and form; *C*, each chromosome splits lengthwise into two, (*B* and *C* are called prophases); *D*, metaphase, the split chromosomes arrange themselves in a plane across the equator of the cell; *E*, anaphase, the chromosomes halves separate with one complete set (eight in this case) going to one pole and the other set to the other pole; *F*, telophase, each new group of chromosomes arranges itself into a thread and a new cell wall begins to appear between the groups

in an atom, part of the energy in the ejected photon causes the Compton recoil electron to be ejected at angle *(b)* and the remaining energy in the incident photon is scattered at angle *(a)* with a change in wave length. The laws of conservation of energy and momentum may be applied to the Compton collision process to permit calculation of the change in wave length of the photon upon scattering. The wave length of the scattered photon will, of course, be longer than the wave length of the incident photon. If the scattered photon has enough energy to eject another recoil electron, the Compton recoil effect may be repeated.

The phenomenon of pair production is shown in Fig. 3C. In the process of pair production all the energy of the photon goes into the formation of the electron pair (electron e^- and e^+) and to imparting energy to the pair formed. This may be represented by:

$$h\nu \rightarrow e^+ + e^- + \text{kinetic energy}$$

The energy equivalent of the electron mass is 0.51 mev. Thus in the pair production process the electron and positron each remove 0.51 mev, or a total of 1.02 mev from the photon. Then 1.02 mev is the minimum energy required for pair production.

For energies below about 160 kv (soft X rays) the photoelectric effect predominates in most materials. This effect decreases with increasing energy and becomes negligible at about 0.3 mev. At this point most of the energy is lost to Compton recoil electrons. Above 1 mev, pair production starts to occur and becomes increasingly important at higher energies.

X ray and gamma radiation will penetrate deep into matter. Because of the low probability that a photon will interact with surface tissue, quanta are absorbed deeper than the surface of the tissue. The ions produced by photonelectron interactions move only short distances from the point at which they were formed, but they will be formed fairly uniformly throughout a mass of the size of the human body, and all tissue in the body will be exposed to injury.

Effects of Ionization on Living Cells. The living cell can be killed as a result of protoplasm ionization or chromosome damage when the cell is bombarded with ionizing electromagnetic energy or accelerated electrons. The protoplasm in a cell is divided into an inner compact nucleus and a surrounding fluid layer. The nucleus is the principal part of the cell. It contains the nucleo-protein which in the process of cell division constitutes thread-like structures known as chromosomes. These chromosomes in the cells provide the mechanism of heredity. The chromosomes are made up of building blocks called genes, which contain the factors that determine the specific qualities of the parent cell and any cells produced by cell division.

All organisms reproduce from a single cell, the ovum. In the union of male and female germ cells, one-half of the chromosomes are contributed by the sperm and one-half by the ovum. Following fertilization, a rapid division takes place. The division follows a definite plan throughout the life of the organism. A complete description of the cell division process may be found in most texts on biology. The process of plant cell division is shown in Fig. 4.

In the process of life, there is a continuous destruction and replacement of cellular tissue within the body of a living organism. The different layers of tissue in an organism contain similar nuclei, but the surrounding cytoplasm is different for each different type of tissue layer. After the organism reaches maturity, cell division levels off, and a balance of cellular death and replacement takes place.

A great deal of information is available concerning the effects of radiation-induced chromosomal breaks and rearrangements. The main concern here is the mechanism by which short-term lethal effects are obtained by ionizing radiation.

When a great number of cells in an organism are destroyed or damaged as a result of ionizing radiation, the repair processes within the cell are stimulated and cell division proceeds at an increasing rate. Damage to the reproductive apparatus of the living cell produces changes in the ability of the daughter cell to survive and multiply.

Sparrow and Rubin (12) point out that the immediate consequences of chromosome breakage are mitotic inhibition and cell death, and that death is more likely to occur when chromatin material is lost. Cells that do survive with chromosome changes and breakages will cause genetic changes. In addition to the actual genetic changes that may be associated with chromosome breakage, sterility or partial sterility, or death, may occur in offspring from damaged cells.

Martin (11) points out that one or two ionizations within a chromosome, break the rod and destroy or eject a gene at the point of rupture. With restitution of the break, cell division will continue, and the successive daughter cells may be normal or abnormal depending on the importance of the gene removed by the process. In the apparently normal daughter cells, the absence of the gene may be manifested much later after numerous divisions. If restitution does not occur, or if multiple breaks occur and the fragments interchange during restitution, the effect will be more serious and death of the cell probably will occur at or following cellular divisions. There may be intermediate effects between these two extremes depending on distribution of chromosome material.

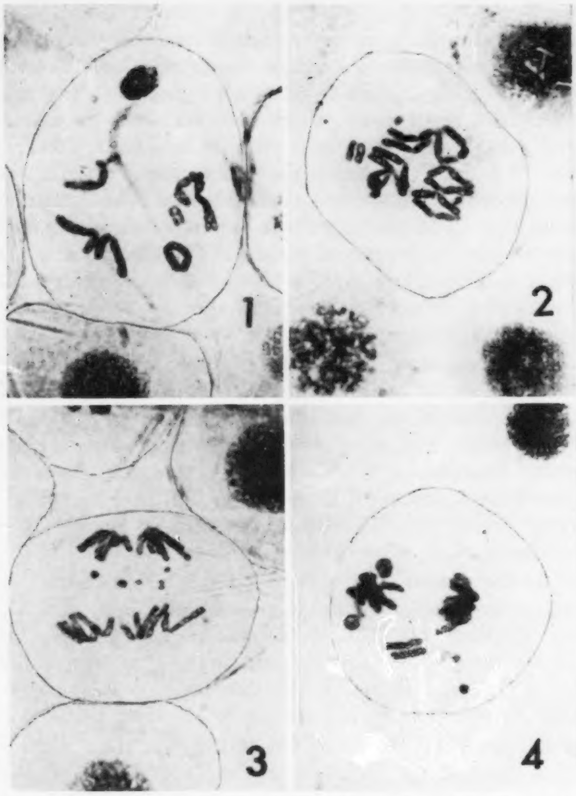

Fig. 5 Photomicrographs of various stages of cell division of a pollen cell from the *Tradescantia reflexa* (Wandering Jew) plant, illustrating the effects of 500 roentgens of X radiation on chromosomes, *(1)* metaphase, *(2)* early anaphase, *(3)* late anaphase, *(4)* early telophase

The photomicrographs presented in Fig. 5 show the effects of 500 roentgens of X radiation on the chromosomes in a pollen cell from the *Tradescantic reflexa* (Wandering Jew) plant. The effects of radiation on a cell of this plant is relatively easy to show in a photomicrograph, because the nucleus in each cell contains only six chromosomes. It would be almost impossible to obtain a clear picture of chromosome damage in the nucleus of an irradiated plant such as wheat because wheat has 42 chromosomes in each nucleus; however, the principles involved are the same for both plants.

Fragments of chromosomes are visible in each of the photomicrographs. Chromosome fragments are clearly visible in the late anaphase state of Fig. 5-3. As the cell progresses to the early telophase stage and then to complete division, the loss of chromosome pigments will probably cause the death of the daughter cell.

Summary

Radiant energy causes two main effects on tissue. These are heating effects and chemical effects. The effect of electromagnetic radiation on biological tissue, with wave lengths longer than about 2880 A, is essentially heating. This includes the radio, radar, infrared, and part of the visible spectrum. The effects of electromagnetic radiation on tissue with wave lengths shorter than about 2880 A causes ionization in atoms which produces chemical effects. Bond breakage in molecules will do the same and perhaps at considerably lower energies.

Actually there is no clear-cut dividing line between the heating effect and chemical effect of radiation on tissue; however, energy in the far-ultraviolet spectrum beginning at about 2880 A, produces some chemical effects in tissue. As the wave lengths of the energy becomes shorter and shorter, for X rays and gamma rays, the chemical effects become more pronounced and the heating effects are negligible.

The effects of ionizing photons of electromagnetic energy and the effects of subatomic particles (electrons, protons, neutrons, etc.) on tissue are somewhat the same. In either case the end result of the absorption of ionizing radiation is the production of ionizing particles and tissue damage is caused by these particles.

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How Research and Development Aid Machinery Design

(Continued from page 807)

stability for the manufacturer. This can be done only if that body is given the opportunity with the right personnel and freedom, to explore the facts of nature and convert them into end products for utilization by the farmer. Individuals must work together as a unit with free interchange of expression at all times. Programs and procedures must be well planned, by screening and evaluating the facts along the highway to success. Striving to keep ahead of competitors is not an immoral act—it is a part of our free economy which has made our nation great.

In conclusion, progress is not measured by what goes into a program. It is measured on what comes out of it. Perfection in design is reached, not when nothing more can be added, but when nothing more can be thrown away.

Surface Soil Reaction to Pressure

C. A. Reaves and M. L. Nichols
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Laboratory apparatus, and tests simulating field conditions, depict reaction patterns of several soils to compaction

THE compaction of soil by field tillage implements or by traffic of other machinery and animals is important because it affects conditions necessary for plant growth. The most important effects are changes in aeration, infiltration capacity, permeability to water, and soil temperature. Tillage is affected largely by the application of pressure in various ways to soil by tillage implements. In some cases the soil may be compacted by the pressures of tillage or traffic to the extent that few or no plant roots penetrate the dense layers. Engineers and soil scientists at the Tillage Machinery Laboratory (USDA) and at the Alabama Agricultural Experiment Station are cooperating with implement manufacturers in studies of the effect of pressures by tillage implements and traffic. This article is a progress report which consists of a brief review of pertinent past work and some of the more recent findings of the laboratory.

Compression of Soil by Tillage and Traffic

Numerous studies have been conducted in the past that pertained to effects of pressure on soil structure. Many of these studies were conducted by engineers to determine how to render the soil impermeable and to determine its ability to resist pressures in dams, foundations, and levees. The most common objective of this engineering work was to produce a firm stable structure of maximum density. From an agricultural standpoint, the tiller of soil desires a loose friable condition that is optimum for the life of soil biologic populations, especially the roots of crop plants. The general basic laws of soil reaction to pressure are the same whether a firm stable structure or a loose friable structure is to be produced, but the methods of producing such different structures are entirely different. It is necessary, therefore, to develop special methods of study and techniques that are specifically adapted to evaluate the effect of tillage operations on surface soil.

Paper prepared expressly for AGRICULTURAL ENGINEERING.

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*Numbers in parentheses refer to the appended references.

During previous studies of tillage machinery at Auburn (1)*, it was found that pressure on the soil by implements and traffic was of primary importance in tillage and methods of studying distribution of pressure through the soil were developed. Some of these basic methods are still in use at the laboratory but the equipment and techniques, in many cases, have been improved materially.

Resistance to Compression of Confined Fragmented Soils

From studies (1) of the resistance to compression of confined fragmented soils by the device shown in Fig. 1, it was concluded that there were two phases of reaction to pressures within the range of this study. One phase consisted of a rearrangement or collapse of the fortuitous structures formed when putting the soil in the container, and the second phase consisted of the resistance to rearrangement produced by cohesion and internal friction. This latter phase involved structural rearrangement of interlocking particles after contact had been made between the soil particles of the mass. Field tillage operations present an analagous situation in that a fortuitous structure is produced mechanically by the implements while the amount and rate of the return of the soil to its more normal physical condition depends in large part upon the soil's intrinsic properties which resist the compacting forces of nature and traffic.

Pressure-compression curves obtained during these earlier studies resembled hyperbolas. Later studies showed that the curves more nearly followed equations of the general form $y=ae^{bx}$ where y indicates the amount of compression and x the pressure, with the relationship being

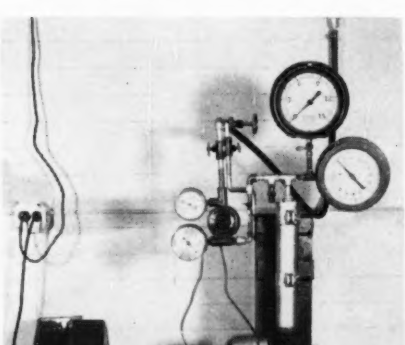


Fig. 1 *(Left)* Apparatus for studying the resistance to compression of confined fragmented soils. Pressure was applied by compressed air and compression was measured by an Ames dial

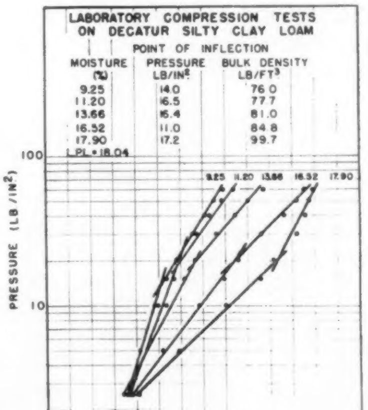


Fig. 2 *(Right)* Resistance to compression of confined fragmented Decatur silty clay loam. Change in slope indicates the transition point from the fortuitous structure to full contact structure

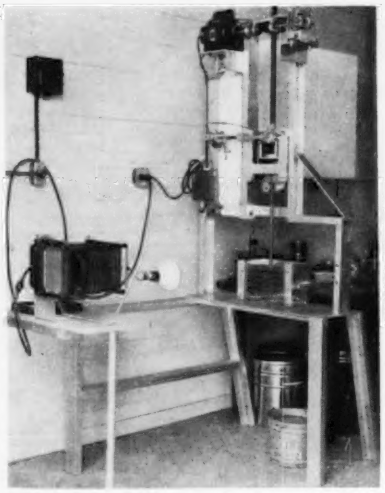
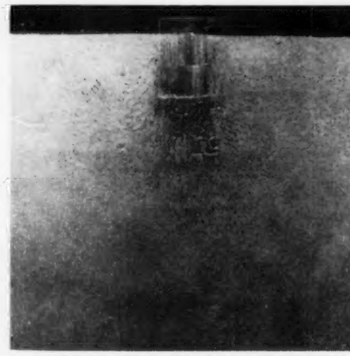


Fig. 3 Apparatus for studying soil movements before a constant-speed, screw-driven plunger.



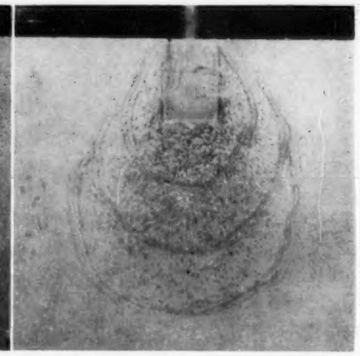


Fig. 4 *(Left)* Movement pattern of loose unconfined fragmented soil (Lloyd clay) before a 1-in plunger • Fig. 5 *(Right)* Movement pattern of fairly compact unconfined soil (Vaiden clay) before a 1-in plunger. The crayon marks show lines of approximate equal pressure for ½, 1 and 1½-in advancements of the plunger

$dy/dx=ky$. This simply states that the increment of compression produced by a given increment of pressure is proportional to the amount the soil has already been compressed. The pressure-compression relationship of the fortuitous structure and the full contact structure is illustrated by the breaks in the curves shown in Fig. 2. The trend for reversal of slope in the high-moisture range was caused by moisture exceeding the lower plastic limit. At still higher moistures free water was released and consolidation ceased. These measurements conformed to the basic mathematical theory of compression developed by Doner (2) who gave the general law of compression for a non-plastic granular media as $(T-Tm)/(To-Tm)=e^{-K(W+F[W])}$ when T is the thickness for a layer at any particular instant, Tm is the minimum thickness attainable without crushing. To is the initial thickness of the layer, K is a constant which is a function of moisture content, and W is pressure.

The bearing capacity of a confined soil depends upon its bulk density, its structure, the resistance of particles to rearrangement, and its moisture content. In these studies the bearing capacity of a fragmented soil was determined by applying pressure and measuring the resulting bulk density through a range of pressures from 2½ to 60 psi. Five moisture contents were used for each soil and they were, as nearly as possible, distributed evenly from air dry through the lower plastic limit. Table 1 gives the data obtained for

TABLE 1. BULK DENSITIES OF CONFINED FRAGMENTED DECATUR SILTY CLAY LOAM
(Pounds per cubic foot)

	Moisture, percent				
Pressure	9.25	11.20	13.66	16.52	17.90
2.5 psi	67.7	68.1	66.9	68.8	70.3
5	70.5	70.5	70.8	75.9	79.3
10	74.3	74.6	76.9	84.0	90.0
15	76.6	78.6	80.9	89.7	97.6
20	79.0	79.5	83.3	92.8	100.6
30	82.8	83.3	88.0	98.0	105.6
40	85.4	86.2	92.1	103.0	107.8
50	87.4	89.0	95.0	105.8	108.3
60	89.7	91.9	98.2	107.5	109.4

the Decatur silty clay loam shown in Fig. 2. Soils with kaolinite (a material which does not swell materially) as the principal ingredient of their clay follow a definite order in the change of slope of the curve when bulk density is plotted against pressure. As the moisture increases, the bearing capacity of a soil decreases so that at or near the lower plastic limit a relatively low pressure may produce a compaction which will affect crop production seriously. As the moisture content approaches the lower plastic limit, the rate of compaction increases rapidly. Above the lower plastic limit very little force is required to produce movement approaching that of a viscous fluid and the rearrangement of structure proceeds with release of free water until all of the voids are filled with water if the entrapped air escapes.

The high degree of swelling with addition of water to the heavy soils that contain a large percent of montmorillonite gave somewhat different curves from those of the kaolinitic soils. There is a tendency to form buckshot-like structures when moistening the fragmented particles of a dry soil by the condensation method. The resulting structural condition is quite similar to that frequently encountered in tilled soils of similar texture in the field. The resulting large aggregates have greater resistance to shear and compression than smaller aggregates of the same material. Apparently the internal force required to hold aggregates together increases with the size of aggregate (3). As a result of these conditions laboratory control measurements of montmorillonites show less variation of bearing capacity

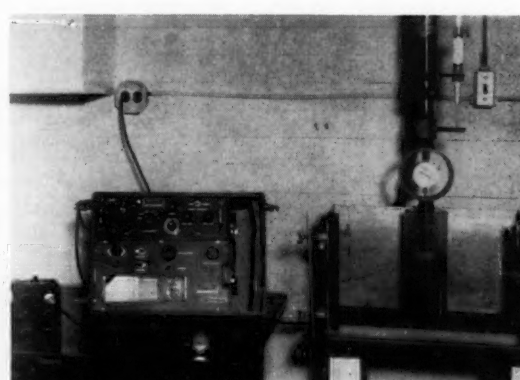


Fig. 6 Apparatus for studying arch action in lucite cylinders. Pressure to the plunger was controlled with a hydraulic jack and an Ames dial in a calibrated test ring. Pressure at bottom of soil was recorded with an electric strain gage and Sanborn recorder

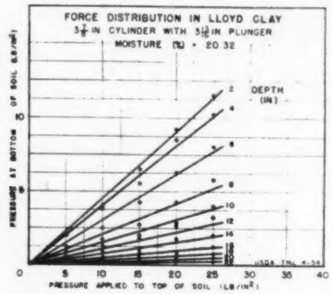


Fig. 7 Relationship of pressure transmitted through Lloyd clay to that applied on the surface

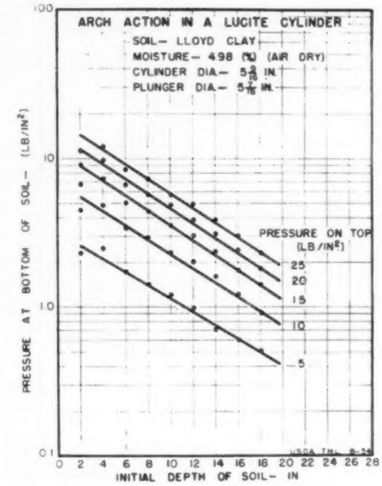


Fig. 8 Relationship of pressure transmitted through Lloyd clay to initial depth of soil

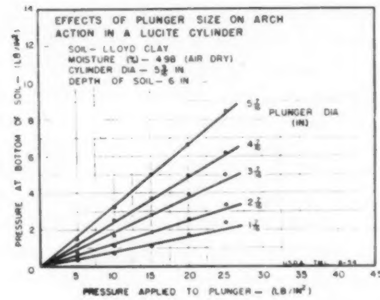


Fig. 9 Effect of plunger size on the amount of pressure transmitted through a 6-in layer of Lloyd clay

with different bulk densities. In the field the swelling exerts large compressive force and the aggregates are compressed. On drying, the aggregates apparently again separate into the same buckshot-like aggregates as before the swelling. With montmorillonites in confined compression tests through the fortuitous structure range, it was found that as moisture increased stability decreased; that is, it takes greater increase in bulk density to produce a given increase in bearing capacity. At the deflection point, above which cohesion and full contact of structural units exist, the reverse was true.

Distribution of Pressure in Unconfined Fragmented Soil (Arch Action)

Previous studies at the Alabama experiment station (1) and the USDA tillage machinery laboratory included special attention to the distribution or vectoring out of unconfined pressure through a soil mass. Since this distribution of pressure is responsible for the formation of arches in soil, this phenomenon was termed arch action. Two methods of studying arch action were used, one a plaster cast method and the other a visual method.

When an object, such as a plunger or penetrometer, is forced into unconfined homogeneous soil, the resulting pressure causes soil to move into areas having least resistance to compression. The pattern or extent of area of this movement is determined largely by the friction of movement and the interlocking of soil particles. Another important factor is the ratio of size of plunger to depth of the compressible material. For a specified unit force on the plunger, the resulting force at any one depth increases as this ratio increases. Tschebotarioff (4) states that when this ratio is small the pressure intensity increases in proportion to the length of the sides of square footings.

Doner (2) derived theoretical mathematical laws of arch action in a granular media. Based upon cohesion and shear below the plastic range of moisture, he developed formulas for calculating the downward and horizontal components of the forces involved.

Several techniques for measuring the soil movements have been used. In the plaster-cast method layers of soil were separated by fine aluminum leaf which permitted the change in shape and density of each layer to be obtained. In the earlier work very fine Italian aluminum leaf, which had extremely low tensile strength, was used to delineate layers of soil which then were subjected to pressure. This leaf was easily visible and did not reduce or dampen soil movement materially. Later, levigated aluminum was used to mark boundaries of layers. A method of coating the surfaces of the glass, which constituted front of soil box with levigated aluminum suspended in alcohol, was developed by Kummer and his associates (5).

Fig. 3 shows apparatus for studying soil movements before a plunger. It consists of a metal box with a glass front coated with levigated aluminum to permit observation of the movement of particles as a plunger is placed against the glass and forced into the soil. The plunger is driven by a motor through a screw drive to give a slow and uniform penetration into the soil. Travel and pressure are continuously recorded. Movement of soil particles at any desired time is recorded photographically. Several of the soils in the laboratory plots have been studied in this manner through a range of bulk densities and moisture contents.

Fig. 4 shows the movement before a 1-in square plunger pressed into the soil. The cone was formed immediately below the plunger and before its advance the soil moved into new positions in the direction of least resistance. When the soil was placed in layers of uniform thickness, it was found that the amount of compression varied inversely with the depth of the layer. The thickness of the layers, when compared with the confined compression values, indicated that the soil moved from in front of the plunger to the sides of the cone.

In unconfined loose soil the curve was complicated by the fact that the location of an individual particle in reference to the plunger was changing constantly as the plunger advanced towards or past the particle. As the plunger moved downward through the soil, the limits of the area where movement occurred could be marked on the glass surface so that the displacement was delineated. These lines were approximately at right angles to the movement lines. Assuming soil uniformity these marks were lines of approximately equal pressure. This is shown in Fig. 5 for three distinct movements of the plunger. Once the cone was formed in a homogeneous soil mass, the penetration of the plunger was directly proportional to the pressure. It was observed that the width and depth of arch for a particular soil and plunger was practically a constant at all compactions. It was concluded tentatively that bulk densities within the limits ordinarily encountered in field soils in good tilth were not an important factor in arch width, but that arch

width was caused largely by the friction and interlocking of particles. Cohesion was considered a secondary factor.

Since the soil movement in compaction is from areas of greater to lesser density, or where soil material is moving into space released by closing of pores, there appears to be some similarity between mathematical equations which express the movement of soil in compaction and the La Placian type of equation used in expressing flow-net relationship in hydraulics of soil water. Further study is needed to establish any relationships useful in evaluating resistance to compaction of tilled soils with various bulk densities and moisture contents.

In preventing the formation of dense layers or in the breaking up of such layers, the depth at which compression occurs is important. This depends upon the arching out of compressive forces in the soil; therefore, special attention was given to the depth at which various pressures were effective in compaction. Attempts at placing electric strain gages in the soil failed because the gages were large and rigid and were supported over a relatively large area compared to the soil particles. This type of apparatus, however, shows promise of great usefulness and its use is being studied by the U. S. Department of Agriculture in cooperation with Michigan State University. In cases where the movement of soil was considerable, and especially when the gage was applying pressure on the soil near the surface, it supported a large percent of the load. In some cases the pressure per square inch on the gage was greater than that of the applied load per square inch. Soehne (6) used a gage similar to the one tried except he had a steel cylinder extending above the sensing element to measure the residual effects of compaction. He also experienced difficulty with this type of cell. Such a condition would exist in a soil with rocks or other rigid materials embedded in the soil which greatly complicates the mechanics of reaction to force application. To overcome this complication in the use of strain gages, the gage was placed with its sensitive face flush with the inside bottom of the box.†

Arch action was evaluated on several soils by using 5⁹⁄₁₆-in diam. lucite cylinders with various sizes of plungers to determine the amount of pressure on the cylinder wall caused by arch action. Fig. 6 shows the test apparatus. Soil was fitted into the cylinder through a range of moistures and bulk densities comparable to that encountered in the field. Tests were made by fitting and applying pressure on a 2-in, a 4-in, a 6-in increment of soil and so on until a depth of 20 in had been tested. All soil was removed after testing each increment. The desired pressure per square inch was applied to the surface of the soil with a hydraulic jack and a calibrated test ring. Pressure transmitted through the soil was recorded by an electric strain gage mounted with the sensing element flush with the bottom of the cylinder. Diameter of the plungers was varied to give desired distances from the edge of plunger to the cylinder wall. In effect, the plunger size varied from 5⁷⁄₁₆ in to 1⁷⁄₁₆ in for a 5⁹⁄₁₆-in cylinder. Pressure was applied to the surface of the soil from 5 to 25 psi in 5-lb increments.

†The electric strain gages used in this study were designed by A. W. Cooper, agricultural engineer (AERB, ARS), U.S. Department of Agriculture. Unpublished data.

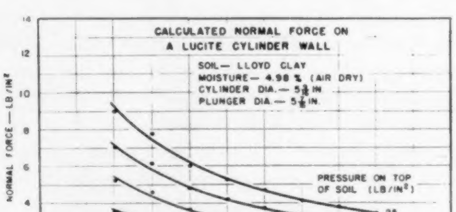


Fig. 10 Calculated normal force on a lucite cylinder wall for each 2-in layer of soil

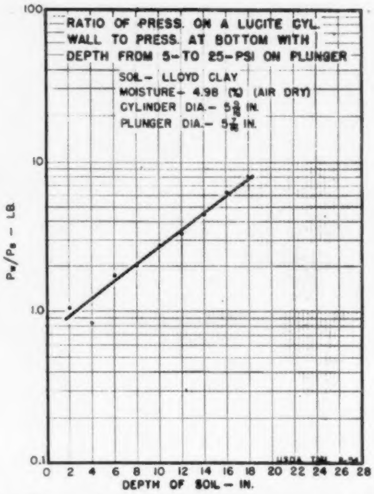


Fig. 11 Effects of interlocking of particles and cohesion on arching of Lloyd clay in a lucite cylinder

Fig. 7 shows the relationship of pressure transmitted through the soil mass to that applied to the surface of the soil. These data were obtained with Lloyd clay at 20.32 percent moisture in a 3⅞-in cylinder with a 3³⁄₁₆-in plunger. Fig. 8 shows the pressure at the bottom of the soil plotted against initial depth of soil on semilogarithmic paper. Note that the data for any specific pressure on the soil surface plotted a straight line and also all of the lines were parallel regardless of the pressure applied to the surface of the soil. This is further evidence of the magnitude and significance of arch action. Fig. 9 shows the effect of plunger size on the amount of force transmitted through a 6-in layer of soil. It should be realized that the total force on each plunger was not equal but the graph gives a good indication of the magnitude of arch action, because the arch width was great enough in all cases for friction on the cylinder wall to absorb some of the force. Fig. 10 shows the calculated normal force on the cylinder wall for each 2-in layer of soil. These points were obtained by assuming that the friction on the cylinder wall was equal for each surface 2-in layer. By subtracting the friction loss for succeeding 2-in layers from the total force applied, it was possible to get a close estimate of the magnitude of force normal to the cylinder wall. After determining the coefficient of friction of soil on lucite for the respective moisture content, the total vertical force absorbed by the cylinder wall was calculated.

Fig. 11 illustrates the significance of arching in soil. It is noted that as the depth increases the ratio of pressure on the cylinder wall to pressure on the bottom increases. Since this soil is relatively dry, the only factor responsible for pro-

(Continued on page 820)

Deep-Bed Rice Drier Performance

S. M. Henderson
Member ASAE

Performance studies of a pilot drying system were conducted in an attempt to arrive at an optimum air rate for drying rice with unheated air. Such factors as moisture content, grain and air temperature, humidity, length of drying time and season of the year were introduced into the test procedure to determine the effect of various performance features upon final rice quality

RICE and other small grains are dried satisfactorily in many areas of the United States in deep-bed, unheated-air driers. These driers consist of bins or granaries of grain which vary in depth from 2 to 20 ft through which air is moved at rates from 0.5 to 6 cfm per bu. The performance of a drying system of this type will be satisfactory if the air distribution is relatively uniform throughout the mass, the air rate per bushel is adequate, and the system is managed properly (5).*

Too low an air rate will permit the grain to spoil before it reaches a safe-storage moisture content. Furthermore, too low an air rate may extend the drying period into the cold, humid winter period where no significant drying can take place and, consequently, delay until spring the time when the moisture content will be low enough for safe storage or for sale at the highest price. Since the power required for a specific system varies approximately as the cube of the air rate, a small excess in air rate could cause a gross excess in size and cost of the air-moving system.

The design, management, and performance of deep-bed, unheated-air drying systems have been treated in general in a number of USDA, state agricultural experiment stations, and industrial publications. Research and experience by these groups have yielded reliable design data for most of the features of this system. Systems with perforated floors and parallel air flow through the grain mass can be designed critically as regards air flow. Although considerable progress has been made in developing design procedures for non-parallel flow systems (3, 4, 6, 7), additional studies must be made to develop general non-parallel air flow design data. Even though satisfactory air rate recommendations and design procedures have been developed by experience for the areas using this drying system, these recommendations are not necessarily optimum.

The studies conducted during the fall and winter of 1954 were designed to attempt to find the optimum air rate for deep-bed unheated-air rice driers for California installations, to determine the effect of various performance features upon final rice quality, and to attempt to apply the findings to other rice producing areas.

Pilot Drying System

A pilot drying system of six 50-gal oil drums was made up as shown in Figs. 1 and 2. Since the performance of a deep-bed drier as regards drying time and final moisture gradients is dependent upon air rate per bushel rather than size, the results of tests in these small containers would be comparable to the performance of a large unit having the same air rate per bushel. Each drum was fitted with a hardware and flyscreen floor and an orifice for measuring the air rate through the stored rice. The orifice diameters were 5/16, 7/16, 5/8, 7/8, 1 1/8, and 1 1/4 in, respectively, so that respective air rates of 0.1, 0.2, 0.4, 0.8, 1.2, and 1.6 cfm per bu could be produced with approximately the same pressure drop across each orifice. Since the Reynold's numbers of the required flows were low, 2560 to 8950, orifice coefficients of Tuve and Sprenkle (9), also found in Brown (1), were used. The required orifice differential, 0.12 to 0.14 in of water, was observed by a micromanometer and adjusted for each orifice by gates in the fan manifold (Fig. 1). A calibrated spring balance was provided to weigh each drum and its contents at frequent intervals to provide a moisture content history. The drums were located in a shed which was closed on three sides. The open side faced north.

A quantity of field-run rice of 24 percent moisture (w.b.) was secured on October 13 and each drum filled level full. The fan was started and operated continuously until the last drum was removed from test on April 11.

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The author—S. M. HENDERSON—is associate professor and associate engineer in the agricultural experiment station, University of California, Davis.

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*Numbers in parentheses refer to the appended references.

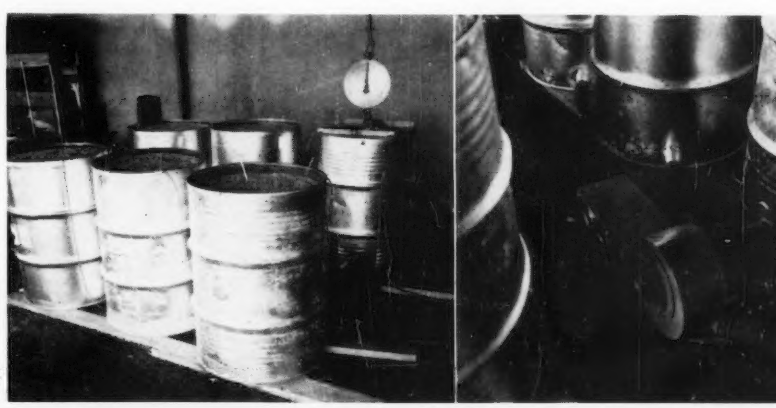

Fig. 1 Pilot drying system showing scale for weighing drums. View at right shows close-up of manifolded fan and rubber tubes for orifice pressure observations

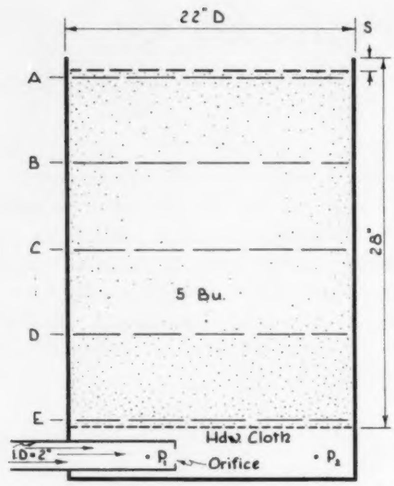

Fig. 2 Cross section of container showing construction and levels where samples were taken

Results

The results are reported in Figs. 3 and 4 and in Table 1. The original moisture content of each drum was determined by a Tag-Heppenstal moisture meter. Subsequent average moisture contents, Fig. 3, were calculated from the original moisture contents and drum weights as time progressed. Each drum was removed from test when the moisture content approached 14 percent, or a definite conclusive trend was indicated. Immediately upon removal from test, the grain was removed in layers and samples taken at the levels noted in Fig. 2. Moisture samples were taken in glass jars which were sealed for about 24 hr to permit moisture equalization prior to moisture content determinations. Samples for milling and germination were taken in paper bags. These samples were stored under outside atmospheric conditions until they were between 13 and 14 percent moisture content which is in the proper range for mill yield tests. The weather data, Figs. 5 and 6, for the period of test were from official weather bureau observations at Davis. The open circles are average daily values for Davis. The 1954-55 averages are for Davis. The normals were from Sacramento data, 16 miles away. The Baton Rouge and Little Rock curves are respective normals for those cities.

The temperature was slightly hotter and the relative humidity much lower than normal from the time the studies were started until November 1. During this period, drums having air rates of 1.2 and 1.6 cfm per bu dried to a terminal moisture content. The remaining drums changed little in moisture content between November 1 and February 9 during which time the relative humidity was above normal and the temperature below normal. Following February 9 the relative humidity lowered and the remaining rice dried continuously until removed from test upon the dates noted in Fig. 3.

The final moisture contents observed at the levels of Fig. 2 are reported graphically in Fig. 4. The drums with 1.2 and 1-6-cfm rates which dried quickly had a greater moisture differential, top to bottom, than the remaining units with lower air rates which required a long drying period. The gross moisture removal rate from a deep-bed drier increases with an increase in air temperature, a decrease in relative humidity, and an increase in air rate. The moisture differential, top to bottom of the mass, will be a minimum if the air temperature is low, relative humidity high, and air rate high. Thus, although the mass as a unit dried quickly due to high temperatures and low relative humidities, the top of the mass dried little and the bottom overdried because the air was loaded with moisture near the bottom of the drum and so had little additional capacity for drying as it moved through the mass. The remaining drums required an extended drying period due to a low air rate and unsatisfactory drying weather during the winter period. Since the relative humidity was high enough during the winter months to cause an increase in the moisture content, a narrowing of the moisture differential would be expected; that is, the bottom of the mass would increase in moisture content faster than the top. This condition is reflected in the final gradients for the four slower air rates, Fig. 4. The 0.8-cfm-per-bu drum was removed from test before the remaining three drums and its gradient is steeper than that of the 0.4-cfm-per-bu drum. The slope of the reversed portion of the gradients, *A* to *B*, is believed due to the taking up of moisture during the winter and convective drying from the surface. The steepness of the 0.1 and 0.2-cfm-per-bu reversals indicates that convective drying may be an important factor in the drying of the surface of a deep bed.

The milling yield of the rice (Table 1) from all except the lowest air rate study was remarkably high. The yield of

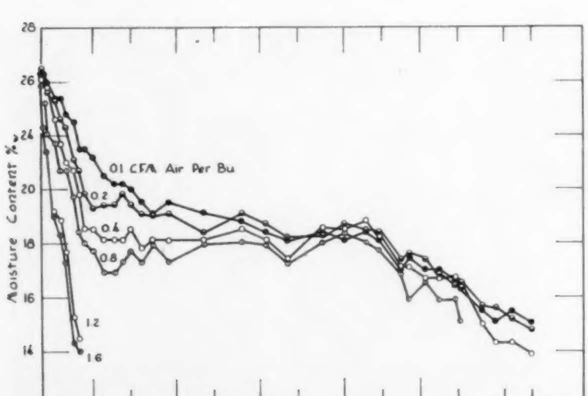

Fig. 3 Average moisture content of each drum during the test period

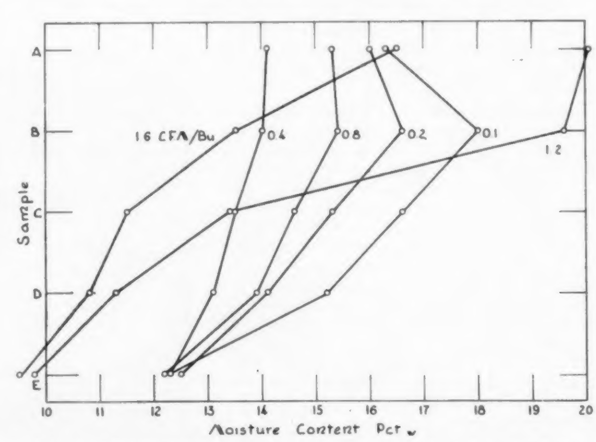

Fig. 4 Moisture gradients through the individual drums when removed from the test. Sampled as noted in Fig. 2

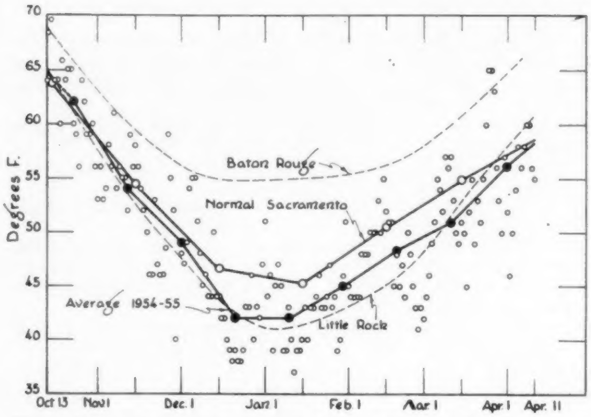

Fig. 5 Daily average temperatures for the test period with normals for Sacramento, Baton Rouge and Little Rock

the lower portion of the drum with 0.1-cfm-per-bu air rate was excellent. The reduction in yield of the lower sample *E,* of the 1.6-cfm-per-bu air-rate drum could have been due to too fast a drying rate resulting from the high air rate or too low a moisture content. Since the drying rate in this region is nearly independent of air rate and the final moisture content is only 0.3 percent lower than that of the 1.2-cfm-per-bu drum, there is no firm evidence that either of these is responsible for this reduction.

The grade of the rice was lowered in the upper portion only in the 0.1 and 0.2 cfm per bu air rate drums.

The germination of rice grown during the 1954 season was generally low and 80 to 86 percent could be considered normal. The viability of quantities that dried at 0.4 cfm per bu or lower was reduced in the upper portions of the mass. The high germination of the *E* sample of the 1.6-air-rate drum is believed random rather than a function of drying conditions.

The mass shrinkage data are probably of little significance since lifting and lowering the drums each time a weighing was made might tend to compact the mass.

Overdrying the lower portion had no effect upon quality. Since the drying rate of the lower layer of grain is independent of air rate, the *E* sample of rice in each drum reached a moisture content as low or lower than 9.8 percent. Since the quality indices of all the *E* samples of Table 1 are comparable to the other sample indices of the higher air-rate

TABLE 1. ANALYSIS OF SAMPLES TAKEN AT LEVELS SHOWN IN FIG. 2 AT TERMINATION OF RESPECTIVE AIR-RATE RUNS

Air rate cfm per bu		0.1	0.2	0.4	0.8	1.2	1.6
Milling yield	A	47/56*	60/70	64/71	59/71	62/69	61/70
	C	56/68	60/70	66/72	63/71	63/71	63/70
	E	62/71	63/70	65/71	62/71	62/71	51/70
U. S. grade	A	S†	No. 5	No. 1	No. 1	No. 1	No. 1
	C	S	No. 2	No. 1	No. 1	No. 1	No. 1
	E	No. 1	No. 1	No. 1	No. 1	No. 1	No. 1
Germination, percent	A	35	58	76	82	57	79
	C	46	53	64	82	84	86
	E	76	83	78	81	86	91
Mass shrinkage, percent		6.2	7.1	8.9	8.9	5.8	7.1

*Pounds of head (unbroken) rice and pounds of total milled rice per 100 lb of rough rice.

†Sample.

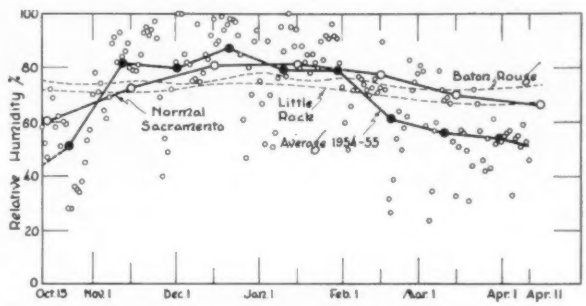

Fig. 6 Daily relative humidity averages during the test period with normals for Sacramento, Baton Rouge and Little Rock

drums, it is concluded that overdrying in this type of drying will not reduce quality.

The equilibrium moisture curve, Fig. 7, was plotted from data from two separate investigations (2, 8). It is included in this paper so that the reader might determine the moisture content of approach for existing relative humidities. For example, during January of this test when the average relative humidity was 80 percent, the rice would approach a moisture content of 14.7 percent. Wet grain would dry toward this value; dry grain would wet up toward this value.

A study of rice-spoilage organisms was conducted by the plant pathology department to determine the temperature — relative humidity relationships to spoilage and darkening of rice seed. Surface-sterilized rice seed was inoculated by spraying with a spore suspension obtained by shaking spoiled rice in water. The seed then was surface dried and suspended on screens in an airtight container. The relative humidity was regulated by use of sulfuric acid solutions placed in the bottom of the containers. A series of cointainers with relative humidities from 80 to 100 percent were placed in controlled-temperature incubators 48 hr prior to suspension of the seed over the solution. They were then left undisturbed for 20 days at which time results were taken. The observations are noted in Table 2.

TABLE 2. RELATIVE ABUNDANCE OF SPOILED SEED OF RICE STORED AT VARIOUS TEMPERATURES AND RELATIVE HUMIDITIES

Relative humidity, percent	Temperature, F 86	77	70	61	53½
	Percent of seeds showing fungus growth				
100	50-60	50-60	50-60	10-50	0
95	50-60	50-60	50-60	0-10	0
90	10-50	0-10	0-10	0	0
85	0-10	0-10	0	0	0
80	0-10	0-10	0	0	0
	Percent of darkened seed				
100	50-60	50-60	10-50	0-10	0
95	10-50	0-10	0-10	0	0
90	0	0	0	0	0
85	0	0	0	0	0
80	0	0	0	0	0

Note that there was no fungus growth on the hull below 85 percent relative humidity and 70 degrees and none under any relative humidity at 53½ deg. Also, the seed was not affected below 90 percent relative humidity at any temperature and below 53½ deg at any relative humidity. Since the deep-bed drying process is thermodynamically adiabatic, the drying air increases in relative humidity and decreases in temperature as it passes through the mass. The possibility of spoilage is minimized since all of the grain is subjected to

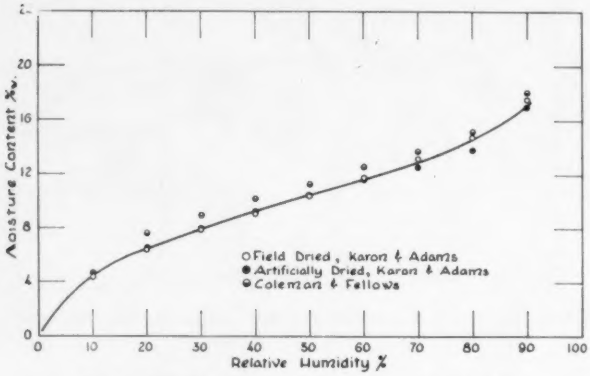

Fig. 7 Equilibrium moisture content of rough rice

either low relative humidity or low temperature as the air passes through the mass. Note also that considerable mold damage on the hull can take place without any kernel damage resulting.

Conclusions

The following conclusions and observations may be drawn from this study:

1 Deep-bed, unheated-air rice driers will produce good quality rice in California if the air rate through the mass is 0.4 cfm or more. However, rates in excess of 1.2 cfm per bu are advisable if high moisture content rice is to be dried to an acceptable delivery moisture content (13.5 percent) before November 1, after which unsatisfactory drying weather can be expected. Since the weather conditions during these tests were close to normal except near the beginning and end of the test when low relative humidities were experienced, a recommendation of 1.0 to 2.0 cfm per bu appears firm for general use in California (5).

2 Rice can be carried through the wet winter period at a high moisture content, over 18 percent in this study, without quality reduction or a decrease in viability.

3 Spoilage organisms are dormant below approximately 85 percent relative humidity or 60 F. Since either relative humidity or temperature are usually below the values noted during winter, spoilage cannot normally be expected to take place even if no drying is done. Since it will aid in keeping the temperature low, continuous fan operation seems advisable except during foggy periods or finely divided rain which might be drawn into the grain mass.

4 A comparison of the normal temperature and relative humidity data for Baton Rouge, Little Rock, and Sacramento, included in Figs. 5 and 6, will show Baton Rouge far superior and Little Rock inferior to Sacramento as regards temperature for drying. The relative humidities of Baton Rouge and Little Rock are comparable and are above the normal for Sacramento during October and below during winter. Due to the higher relative humidity of Baton Rouge and Little Rock during October a higher air rate would be required to complete drying by the end of October. Considering the drying potential as a function of the differences between equilibrium relative humidity and atmospheric relative humidity times the saturated vapor pressure at the drying air temperature, an air rate increase of approximately 10 percent would be expected for Baton Rouge and 30 percent for Little Rock to provide performance comparable to that of this study.

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Surface Soil Reaction to Pressure

(Continued from page 816)

ducing force normal to the cylinder wall is interlocking of particles. At higher moisture contents up to the lower plastic limit, the ratio of pressure on the wall to pressure on the bottom would increase at a greater rate because of cohesion. Above the lower plastic limit this ratio would decrease again as the distribution of force approached that of a fluid.

Summary

The amount that a confined fragmented soil will compress was found to be proportional to the amount that it has already been compressed. It has been found that there are two rather definite phases of reaction to pressure in loosely packed confined soil. One phase consists of the collapse of the loose fortuitous structure and the second phase consists of rearrangements of particles that are controlled by cohesion and internal friction.

In the unconfined fragmented soil, distribution of pressure was studied qualitatively and quantitatively. The qualitative study was made with a box which had a glass front coated with levigated aluminum. Any movement of a soil particle in contact with the glass produced a mark in the aluminum and the general pattern of movement was observed. After an attempt to measure the magnitude of forces in the soil mass with an electric strain gage failed, a lucite cylinder with various sizes of plungers was used to determine the effectiveness of the arch quantitatively, that is, the ratio of pressure absorbed by the wall to the pressure on the bottom at different depths. It was concluded that bulk densities within the limits ordinarily encountered in field soils in good tilth are not an important factor in arch width, but that arch width is caused largely by the friction and interlocking of particles with cohesion a secondary factor.

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NEWS SECTION

ASAE Meetings Calendar

December 12 to 14 — WINTER MEETING, Edgewater Beach Hotel, Chicago

January 20 — MICHIGAN SECTION, Owosso City Club, Owosso.

December 29 and 30 — PACIFIC COAST SECTION, Tucson, Ariz.

February 6-8—SOUTHEAST SECTION, Atlanta, Georgia

March 2 and 3 — Southwest Section, Grim Hotel, Texarkana, Tex.

June 17-20—49TH ANNUAL MEETING, Hotel Roanoke, Roanoke, Va.

NOTE: Information on the above meetings, including copies of programs, etc., will be sent on request to ASAE, St. Joseph, Mich.

Nominations Announced for 1956-57 ASAE Officers

NOMINATIONS for elective officers of the American Society of Agricultural Engineers for 1956-57, have been reported by the Nominating Committee, E. L. Barger (chairman), O. C. French, and F. P. Hanson. Voting will be by letter ballot to be mailed to voting members in February. Closure of voting will be March 31. Vacancies to be filled are those due to expiration of terms of office of three members of the Council at the time of the annual meeting in June, 1956. The nominees are as follows:

NOMINEE FOR PRESIDENT

Roy Bainer was born near Ottawa, Kansas. He received a B.S. degree in agricultural engineering from Kansas State College in 1926. Following graduation he remained at Kansas State as instructor in the department of agricultural engineering, continuing his studies to earn an M.S. degree in 1929. During this time he had become assistant professor and assistant agricultural engineer in the engineering experiment station. In 1929 he transferred to the University of California with the same titles. He became associate professor in 1937 and was advanced to professor in 1943. He was appointed as chairman of the department of agricultural engineering in 1947 and is serving in that position at the present time. In 1952 he was also appointed assistant dean of engineering of the University of California, at both the Berkeley and Los Angeles campuses.

In his early teens Mr. Bainer spent three summers as a field worker for the USDA Cereal Experiment Station at Amarillo, Tex. Later he worked on the assembly and test floor for two manufacturers of engines, and served as a field service man for Twin City Tractor Co., Scott City, Kan. Starting in 1919 and continuing through 1924, he operated a farm in western Kansas as a supplement to his college program, producing over 16,000 bushels of winter wheat during that period.

He has enjoyed the satisfaction of witnessing many advances in agricultural practices, resulting directly from studies he had made or projects he had been associated with. One such development was the harvesting of rice by direct combining, followed by artificial drying. He devised a windrow-harvesting method whereby the heads were rolled inside the windrow to protect them from exposure damage from the sun. It reduced not only the sun damage but also the costs of harvesting. Artificial drying of rice was based on methods used in Italy, and a report by Mr. Bainer on the foreign practices provided the pattern for the development of drying equipment.

His analysis of forces applied to lima beans during threshing, resulted in his suggestions for thresher design changes including the use of rubber rolls. In work he shared on fires caused by sparks from the exhaust of internal-combustion engines provided a basis for the design of spark arresters, thereby reducing farm fire hazards.

His discovery that a sugar beet seed could be reduced to segments, each containing approximately one germ, and his later find-

ROY BAINER

ing of an improved method of processing seed known as decortication, as well as the major role he played in transforming beet culture from one of the most laborious to one of the most highly mechanized agricultural operations, attracted world-wide attention. Visitors have come to his laboratory from Europe, South America and also from the Orient. In 1945 the Ministry of Agriculture of Great Britain requested the University of California for the loan of Mr. Bainer for three months "to obtain the benefit of United States expert knowledge on the mechanization . . . of sugar beets and particularly on the segmenting of sugar beet seed. . . ."

Other studies in which he has engaged include the crusher-mower and dehydration methods for hay, vetch harvesters, stationary spray methods, pre-emergence spraying for weed control, castor bean threshing, and bulk handling of grain. He was a collaborator in creating the internal-combustion nut cracker, which literally blasts the shells from English walnuts without marring the meats.

A member of ASAE since 1927, he has served as chairman of the Power and Machinery Division, chairman of the Pacific Coast Section, and chairman of the College Division. He was elected a Fellow in 1946, and was awarded the Cyrus Hall McCormick Medal by the Society in 1948.

He holds active membership in American Society of Engineering Education, American Society of Sugar Beet Technologists, Sigma Tau, Gamma Sigma Delta, Phi Mu Alpha, Sigma Xi, Sigma Alpha Epsilon, Commonwealth Club, Rotary Club, Methodist Church and Davis Chamber of Commerce.

He is co-author of two books in the Ferguson Series—"Tractors and Their Power Units" and "Principles of Farm Machinery."

NOMINEES FOR VICE-PRESIDENT

Talcott W. Edminster is a native of Massachusetts and an engineering graduate (agricultural engineering major) from the University of Massachusetts in 1942. He received an M.S. degree in agricultural engineering from the University of Georgia in 1943.

His first employment following graduation in 1942 was as a field construction engineer with the Turner Construction Co. in Boston. He resigned in the fall in favor of continuing his education as a graduate research assistant at the University of Georgia. In 1943 he joined the staff at the Virginia Agricultural Experiment Station, Blacksburg, as an assistant agricultural engineer. After one year he was assigned to the Soil Conservation Service, USDA, Blacksburg, as an agricultural engineer. In this position, he initiated a drainage research program in Virginia and assisted state cooperators in initiating irrigation studies. He co-developed with state and federal personnel the double-cut-plot mulch-tillage principle. Also, he formulated a program of research on farm pond seepage control.

He was transferred to his present position in the Soil and Water Conservation Research Branch (ARS), U.S. Department of Agriculture, Beltsville, Md., in 1953. In this position he serves as work project leader for the federal drainage research program in

Nominees for Vice-President

T. W. EDMINSTER

P. T. MONTFORT

Nominees for Councilor

C. G. E. DOWNING

D. C. SPRAGUE

the eastern 31 states. He is also responsible for the agricultural engineering phases of the irrigation, tillage and erosion-control practices research programs of the section.

A member of the Society since 1942 he has served as vice-chairman of the Southeast Section and the Virginia Section. In 1953 he was vice-chairman of the Soil and Water Division and chairman in 1954. At the present time he is chairman of the Division's Steering Committee. He has served as chairman of the Virginia chapter of the Soil Conservation Society of America and as chairman and member of the board of directors of the soil conservation section of the Association of Southern Agricultural Workers. He also holds membership in the American Geophysical Union, American Society of Agronomy, Soil Science Society of America and the International Soil Science Society. He has been elected to Phi Kappa Phi and Sigma Xi. He is the recipient of both the USDA Superior Service Award and the William A. Jump Memorial Award For Exemplary Achievement in Public Administration.

He is co-author of "Soil and Water Conservation Engineering," a Ferguson Foundation Agricultural Engineering Series text.

Peter T. Montfort is a native of Texas. He received a B.S. degree in agriculture, majoring in agricultural engineering from the A & M College of Texas in 1921. Following graduation he operated his own farm in North Texas for five years, returning to Texas A & M in the fall of 1926 to do graduate work. A large part of his graduate work was spent in designing, constructing and testing a portable hay drier. Six weeks were spent in collecting, tabulating and summarizing data for a bulletin on large-scale cotton production. He also had the opportunity to assist in a rural electrification survey conducted at that time.

In January, 1928, he was made assistant secretary of the Texas Hardware and Implement Association. In November of the same year, he returned to the agricultural engineering department at Texas A & M as project director of the newly organized Texas Committee on the Relation of Electricity to Agriculture. He has served in that capacity to the present time, with the exception of 1933 and 1934, when he was a county agricultural agent in West Texas. His experience has been primarily in research and leader training in the field of farm electrification.

A member of the Society since 1928, he has served on the Council and has been active in the Rural Electric Division. He has occupied all of the offices in this Division and serves regularly on one or more of its committees. At present, he is a member of the Division's Steering and Program Committees.

He has been the author of a number of papers on various phases of farm electric utilization. He is a member of Tau Beta Pi.

Nominees for Councilor

C. Glenn E. Downing was born in southwestern Saskatchewan, where he grew up on a mechanized farm. He received a B.S. degree in agricultural engineering from the University of Saskatchewan in 1940. At the University, he was active in senior hockey and COTC band activities. During his years at college and following graduation until 1942, he was employed by the Dominion Experimental Farm at Swift Current, Sask., on power and machinery testing and experimental work. One year was spent on irrigation ditch construction and maintenance with the Eastern Irrigation District at Brooks, Alta.

He served in the Canadian Armed Service from 1942 to 1945 in the Royal Canadian Electrical and Mechanical Engineering Corps in Canada, Britain and Europe. Upon return from overseas, he was appointed to head the department of agricultural engineering at the Ontario Agricultural College where a professional curriculum in agricultural and mechanical engineering recently has been instituted in co-operation with the University of Toronto. During this time, he took time off as department head to obtain an M.S. degree in agricultural engineering from Iowa State College.

He has presented and published a number of papers on agricultural engineering, primarily in power and machinery and farm structures. In the latter field he was a 1951 ASAE paper award winner as co-author. He is a past-chairman of the North Atlantic Section of ASAE and has been active on the Animal Shelter Ventilation Committee. He was appointed in 1955 as vice-chairman of Education and Research Committee, ASAE, and also to the Academic Committee of the Agricultural Institute of Canada.

A member of ASAE since 1941, he is also a member of Engineering Institute of Canada, Agricultural Institute of Canada, American Society for Engineering Education and a registered professional engineer in the Province of Ontario. He has been elected to Gamma Sigma Delta and Phi Kappa Phi.

David C. Sprague is a native of Iowa. He received a B.S. degree in agricultural engineering from Iowa State College in 1928 and an M.S. degree from Pennsylvania State University in 1931. From 1928 to 1931 he was an agricultural engineering staff member at Iowa State College where he taught and gained experience in dairy products and the maintenance of dairy manufacturing and refrigeration equipment. In 1931 he accepted a position at Pennsylvania State University where he continued his education and later became professor in agricultural engineering. For twenty years he taught courses in farm utilities, tractors, farm machinery, creamery mechanics, farm shop practices, dairy engineering and agricultural engineering problems.

In 1951 he accepted the position he now holds as buyer and director of specifications and quality control for the farm supplies division, the Cooperative Grange League Federation Exchange, Inc., Ithaca, N. Y.

His research and teaching background is broad and varied to the extent that it falls within more than one division of the Society. He has done work in farm machinery, farm structures, and rural electrification, with his most recent interest being in the mechanization of poultry production. His research work included such projects as methods of heating hotbeds, labor-saving devices for production of vegetable crops, and the improvement of trout streams. He also had an opportunity to conduct a series of farm mechanics meetings for vocational agriculture teachers.

A member of ASAE since 1928, he has served on several of the Society's committees. He is a past-chairman of the Pennsylvania Section and presently is vice-chairman of the North Atlantic Section. He was elected to Sigma Xi.

Nominees for Nominating Committee

Charles E. Ball, associate editor of *Farm Journal*.

Walter M. Carleton, agricultural engineering department, Michigan State University.

J. Robert Dodge, head, farm housing and plan exchange, Farm Buildings Section (AERB, ARS), USDA.

G. Wallace Giles, head, agricultural engineering department, North Carolina State College.

Keith L. Pfundstein, manager, agricultural engineering division, Ethyl Corp.

H. S. Pringle, extension rural electrification specialist, Extension Service, USDA.

Russell R. Raney, chief engineer, New Idea Farm Equipment Co., Coldwater, Ohio

J. Roberts, chairman, agricultural engineering department, State College of Washington.

James B. Stere, product manager, crop driers, New Holland Machine Co.

Ben G. Van Zee, chief engineer, automotive division, Minneapolis-Moline Co.

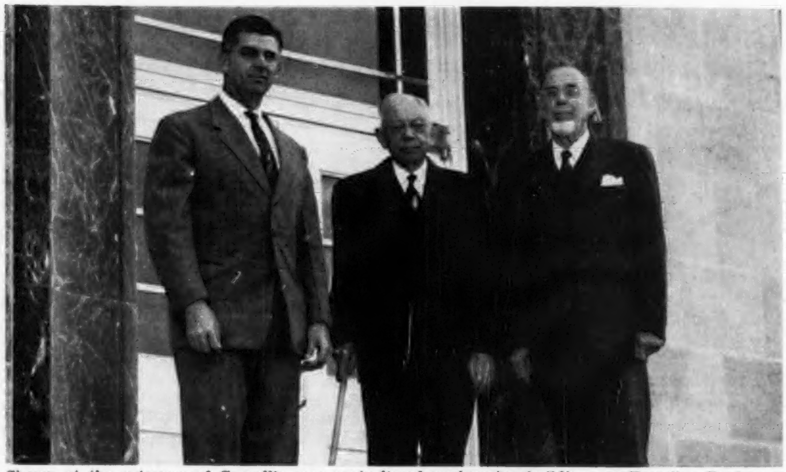
Four Elected ASAE Fellows

THE Council of ASAE recently elected the following members to the grade of Fellow in the Society: J. R. Carreker, Frank Irons, Fred A. Kummer and Harold D. White.

John Russell Carreker was born in Cook Springs, Ala. He received a B.S. degree in 1930 and an M.S. degree in 1933 in agricultural engineering from Alabama Polytechnic Institute, Auburn. He served as a rural electrification trainee with Westinghouse Electric and Mfg. Co. from 1930 to 1932. In 1933 he became an engineer at CCC (Civilian Conservation Corps) Camp, Glencoe, Ala. and in 1934 he became superintendent of a CCC camp at Dadeville, Ala. In 1935 he joined the Soil Erosion Service, Dadeville, Ala. as assistant project engineer. He became project engineer with the Soil Conservation Service, at Anniston, Ala., in 1935 and served until 1938.

In 1938 Mr. Carreker accepted a position of agricultural engineer at the Southern Piedmont Conservation Experiment Station, USDA, and agricultural engineering department, College of Agriculture, Watkinsville, Ga. His duties included the responsibility for research studies, including rainfall, runoff and soil loss measurements, mulch tillage, terracing, irrigation and managing experimental farm unit on the experiment station. In September, 1955, he became superintendent of the Southern Piedmont Conservation Experiment Station. He has served as chairman of the Georgia Section of ASAE, vice-chairman of the Southeast Section of ASAE and chairman of the Society's erosion control group, Soil and Water Division.

Frank Irons was born at Lebanon, Ohio. He attended Ohio State University and received a B.S. degree in agriculture in 1924. He was employed by the Ohio State Education Department and taught tractor short courses each winter during 1925 to 1927. In March, 1927, he accepted employment with the USDA Bureau of Entomology at Toledo, Ohio, and was assigned to development and design studies on harvesting and stalk handling equipment for corn borer control. In 1931 he was transferred to South Norwalk, Conn., with responsibility of continuing the corn borer machinery research throughout New England. He was transferred to Mooretown, N. J., in 1933, and was assigned to study equipment for the control of the Japanese beetle. In 1937 he returned to Ohio and the following year he



Shown at the entrance of Cornell's new agricultural engineering building are Emeritus Professors Byron B. Robb and Howard W. Riley *(Center* and *Right)*, former department heads and pioneers in rural engineering in whose honor the building has been named. At left is Orval C. French, present department head. The new structure, Riley-Robb Hall, is expected to be open in January.

was chosen to direct the Pest and Plant Disease Control Machinery Laboratory, Toledo. Under his leadership the work of the laboratory has been devoted primarily to equipment for the application of insecticides and fungicides, including both ground and aerial applicators.

Mr. Irons was responsible for much of the work in the development of machines for mixing and spreading poison bate for grasshopper and Mormon cricket control, during 1938 to 1946. He has served as a member of the Society's Agricultural Aviation Committee and is a member of the Flying Farmers.

FRED A. KUMMER was born in Frankfurt, Germany. He came to this country in 1928 and worked as a machinist to finance his education in obtaining a B.S. degree in mechanical engineering in 1935 and an M.S. degree in agricultural engineering in 1937 from Alabama Polytechnic Institute, Auburn. He accepted a position of assistant agricultural engineer in research, power and machinery at API and served in that capacity from 1935 to 1939, when he was advanced to associate professor in teaching and research. From 1941 to 1948 he was associate agricultural engineer in research, farm power and machinery, and soil and water conservation. During World War II he was awarded a War Department citation for consultant service to the armed forces in the field of traction and mobility of military vehicles.

Mr. Kummer became head of the API agricultural engineering department in 1948. He served as a member of the ASAE Council from 1949 to 1951, and has been chairman of the Alabama Section and Southeast Section of ASAE, and the Society's Research and Education Division.

HAROLD D. WHITE was born in Sugarvalley, Ga. He received a B.S. degree in agricultural engineering from University of Georgia in 1934 and an M.S. degree in agricultural engineering from Iowa State College in 1938. He did work toward a doctorate at Iowa State College in 1939 to 1941. From 1934 to 1937 he was professor of farm mechanics at Abraham Baldwin Agricultural College. During this period he served part time for one year as resident engineer, University System of Georgia, Atlanta. In 1937 he attended Iowa State College for advanced study, and served from 1938 to 1941 as an instructor of agricultural engineering. In 1942 he returned to his native state as assistant professor in agricultural engineering at University of Georgia. He became associate professor in 1945 and full professor in 1949.

During World War II he was assigned to special work in the Georgia Department of Education as special supervisor, food production war training program. He is past-chairman of the Georgia Section of ASAE and has served as chairman, vice-chairman and secretary of the Societies Southeast Section.

Joint Irrigation Meeting

A JOINT meeting of the Soil and Water Division of the American Society of Agricultural Engineers and the Sprinkler Irrigation Association was held October 26 at the Broadmoor Hotel, Colorado Springs, Colo.

The morning session opened with a talk on sprinkler irrigation design and labor requirements for corn by Paul E. Schleusener, agricultural engineering department, University of Nebraska. His report was followed with a talk by Gilbert Levine, agricultural engineering department, Cornell University, on the effect of sprinkler irrigation on infiltration and soil structure. A panel discussion on evaluating consumptive use by crops concluded the morning session. Wayne D. Criddle, Utah State Agricultural College, was moderator. Lloyd L. Harrold, Agricultural Research Service, USDA, Coshocton, Ohio, and A. W. Raney, department of agronomy, Mississippi State College were panel members. E. H. Kidder, agricultural engineering department, Michigan State University, and co-chairman of ASAE-SIA joint irrigation committee, presided at the morning session.

H. H. Nuernberger, head, agricultural division, Aluminum Co. of America, and co-chairman of ASAE-SIA joint irrigation committee, presided at the afternoon session. Speakers and topics for the afternoon session included John L. Wiersma, agricultural engineering department, South Dakota State College, on the effect of wind on sprinkler irrigation distribution patterns; K. R. Frost, agricultural engineering department, University of Arizona, on evaporation losses for sprinkler spray; Roy C. Garrett, agricultural engineering department, A. & M. College of Texas, on sprinkler irrigation of cotton in the higher rainfall belt, W. E. Code, irrigation engineer, Colorado A. & M. College, on development of underground water resources for sprinkler irrigation; E. H. Kidder, on effectiveness of sprinkler irrigation equipment for frost protection, and M. D. Thorne, Agricultural Research Service, USDA, on suggested irrigation research for humid regions.

New AE Building Named In Honor of Engineers

A NEW agricultural engineering building at New York State College of Agriculture at Cornell University will be named Riley-Robb Hall, in honor of Emeritus Professors Howard W. Riley and Byron B. Robb, pioneers in agricultural engineering.

Orval C. French, head of the agricultural engineering department reports that the 2½ million-dollar building will be nearly completed by January 1.

Professor Riley organized the agricultural engineering department in 1907 and was its head until 1944. He continued his connection with the department, however, until June 30, 1947. He has been well-known among students for his teaching of introductory courses in farm mechanics. He also conducted courses in structures, surveying, and dairy mechanics. He is a native of East Orange, N. J., and received a degree in mechanical engineering from Cornell's Sibley College of Engineering in 1901. He is a Charter and Life Member, past-president and Fellow of the American Society of Agricultural Engineers.

Professor Riley conducted an early demonstration of horse-drawn grain-combine harvesters and also staged one of the first tractor demonstrations in New York state. He did research on fencing, milk cooling, milk tank insulation, electric fence controllers, and devised the basic plan now used for building natural-draft barn ventilation outtake flues.

He is well known for bulletins on sewage disposal that included the design of a concrete septic tank widely recommended by engineers and on knots and hitches which became the pattern for that section in the Boy Scout Handbook.

Professor Robb, who headed the department from 1945 to 1947, was Cornell's first student in agricultural engineering.

A native of Webster, N. Y. (Monroe County), he was largely responsible for the development of extension work in the agricultural engineering department and was project leader until 1935. He pioneered in several fields of extension teaching, notably in land drainage and in care and repair of farm machinery and household equipment.

Professor Robb developed a course in household mechanics for women which included home water supply, pumping and plumbing, electric wiring and motors, care and adjustment of sewing machines, and automobile maintenance. He retired June 30, 1950. He is a Member of the American Society of Agricultural Engineers and past-chairman of the North Atlantic Section.

National Dairy Engineering Conference, March 13 and 14

THE Fourth Annual National Dairy Engineering Conference will be held March 13 and 14 at the Kellogg Center, Michigan State University, East Lansing. Suggestions for speakers may be sent to Carl W. Hall, agricultural engineering department, Michigan State University.

ASAE MEMBERS in the News

J. F. SCHAFFHAUSEN

T. K. SWEARINGEN

V. G. FUHRWERK

D. D. CERNY

W. E. GROENEVELD

D. R. SCHEFFLER

J. F. Schaffhausen has been appointed to the board of directors of Cockshutt Farm Equipment, Inc., Bellevue, Ohio. Schaffhausen is assistant president and director of operations for the company.

Since February, when he was appointed director of operations, he has been supervising all manufacturing, distribution and sales activities for the company. He also serves on the board of, or directs, several investment, agricultural research, and publishing companies.

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Thomas K. Swearingen has been appointed manager of agricultural department of Masonite Corporation. He succeeds Harley M. Ward, who will retire September 1, 1956, after 25 years in that position.

Mr. Swearingen came to Masonite after three years with the Campbell-Ewald Co., Detroit advertising agency. As an assistant account executive, he edited Stran-Steel Corporation's dealer house organ and established an employee house organ for Great Lakes Steel Corp.

Previously he was a reporter on the *Denver Post* and an associate editor of the *Record Stockman.* He also served four years with the U.S. Army Air Force in World War II. He is a member of the ASAE Committee on Public Relations.

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Appointment of **Victor G. Fuhrwerk** as senior project engineer, and **Daryl D. Cerny, Wilbur E. Groeneveld** and **David R. Scheffler** as junior project engineers has been announced by New Idea Farm Equipment Co., Coldwater, Ohio.

Mr. Fuhrwerk has five years experience as a test engineer and product designer. He was graduated from Iowa State College in 1950 with an M.S. degree in agricultural engineering, and also served as an instructor during his final year.

Mr. Cerny's previous experience includes design engineering and work as an electrification advisor. He was graduated in 1950 with a B.S. degree in agricultural engineering earned at San Diego State College and the University of Nebraska.

Mr. Groeneveld has worked as a design engineer since 1953 graduation from South Dakota State College with a B.S. degree in agricultural engineering.

Mr. Scheffler was graduated from Purdue University with a similar degree in 1953 and since that time has worked as a layout draftsman.

•

Billy R. Stewart has accepted a teaching position in agricultural engineering at Texas Technological College, Lubbock. Prior to his new assignment, he served as a surveyor with the Shell Oil Co. in the Odessa oil fields.

•

John M. Ross recently accepted employment with the Hawaiian Pineapple Co., Wahiawa, Hawaii. He was previously in the product planning department, Tractor and Implement Division, Ford Motor Co.

•

James W. Dickens, who has completed requirements for an M.S. degree in agricultural engineering at North Carolina State College, Raleigh, has been appointed research instructor in agricultural engineering. He will devote full time to the problems associated with the curing and drying of peanuts.

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James H. Elliott, Jr., recently resigned as irrigation engineer for Al Khary Farms at Dhahran, Saudi Arabia, to accept appointment as agricultural officer (hydrological engineer) with FAO in Khartoum, Sudan.

Todd V. Crawford has reported a change in military address. He is now with Det. 17, 9th WEARON, Altus AFB, Oklahoma.

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William H. Friday, who has been pursuing graduate study in agricultural engineering at Michigan State University, recently accepted appointment as an instructor on the agricultural engineering staff at Purdue University, Lafayette, Ind.

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Julian M. Fore recently resigned his position in the engineering department of the Tractor & Implement Division, Ford Motor Co., to accept appointment as head of the agricultural engineering department at the University of Massachusetts, Amherst.

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Allen K. Gillette, formerly a farm service advisor of the Detroit Edison Co., is now doing graduate work for an M.S. degree in agricultural engineering at Michigan State University, East Lansing.

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J. W. Harwell recently transferred from his position as area conservationist, Soil Conservation Service, USDA, at Tifton, Ga. to a similar position with SCS at Gainesville. In his new work he will specialize in the small watershed approach to soil and water conservation work with the soil conservation districts.

A. J. Strautman is now associated with Imperial Oil Limited, Edmonton, Alta., as farm service engineer. He has recently been employed as a junior blockman of Allis-Chalmers, Rumely, Ltd., at Calgary.

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Saint Elmo Dowling, formerly employed as an agricultural engineer with the Moore Dry Kiln Co. at Jacksonville, Fla., has resigned his position to establish his own business to be known as the Dowling Equipment Co. at High Springs, Fla.

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Stanley E. Hill has dissolved his partnership in an International Harvester dealership to accept an engineering position with the Eversman Manufacturing Co., Denver, Colo.

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D. Woodrow Cochran, a production trainee of the Ralston Purina Co., was recently promoted to night general foreman of the company's plant at Lafayette, Ind. This position is one step in the company's policy of training future plant superintendents.

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James E. Albritton, who has been employed as a draftsman of the National Fireworks Ordnance Corp. at Camden, Ark., has resigned to accept an assignment as agricultural engineer with the Arkansas agricultural mission in Dinisa, Republic of Panama, for two years. The mission, from the University of Arkansas, operates under the old Point IV program to provide technical advice to the Instituto National de Agricultura at Dinisa.

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Walter R. Friberg has resigned his position with the agricultural engineering department of the University of Idaho to accept an assignment with the International Cooperation Administration in Pakistan. Mr. Friberg has been at the University of Idaho since graduation and has held the position of associate professor and associate agricultural engineer in the agricultural experiment station.

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John E. Dixon has been promoted from the status of instructor in the agricultural engineering department, University of Idaho, to the position of associate professor and associate agricultural engineer in the agricultural experiment station, succeeding W. R. Friberg, and will specialize in farm structures. He is a graduate of Oregon State College and has been on the Idaho staff for a year.

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Eldred A. Jordan has accepted a position as associate county agricultural agent in Conzales, Texas. Formerly he was an instructor in agricultural engineering, Texas Technological College, Lubbock.

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Charles L. Dean has joined the staff of *Farm Implement News* as assistant editor, after having completed two years in the U.S. Army. He received a B.S. degree in agricultural engineering from the University of Arkansas in 1953. He was previously employed by John Deere Waterloo Tractor Works.

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Stephen A. Daniels, formerly with the U.S. Geological Survey in Arlington, Va., is now with the U.S. Department of Agriculture, Soil Conservation Service, Carrollton, Georgia.

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Kenneth V. Anderson has accepted a position as director of industry relations with The Conservation Foundation, New York City. Previously he was managing editor of *Electricity-on-the-Farm* magazine and later with *Better Farming* magazine.

With the ASAE Sections

Michigan Section

A MEETING of the Michigan Section will be held at Owosso City Club, Owosso, on January 20.

Robert J. Alpers, section vice-chairman, will preside. Land and water utilization will be discussed by E. H. Kidder of the agricultural engineering department, Michigan State University. This includes erosion aspects, water rights, municipal water requirements and other factors influencing the use and availability of agricultural land. Henry N. Luebcke of the G. Greiner Co. and agricultural engineering consultant on the Ohio turnpike, will speak on the subject of improved agricultural drainage through better highway design.

After luncheon, a tour is planned of the Michigan Vitrified Tile Co. plant at Corunna to observe the manufacture of agricultural draintile. Also on the afternoon program Dale Friday, chief agronomist, Nitrogen Division, Allied Chemical and Dye Corp., Indianapolis, Ind., will discuss today's fertilizers.

The high light of the program is an address by George D. Scarseth, American Farm Research Association, on food and fiber.

Over 200, including guests and wives, attended the Michigan Section meeting held October 22 at East Lansing. H. J. Barre, consulting agricultural engineer, Mansfield, Ohio, conducted the program on future machines and methods in corn production, which included talks by R. Cook, head of soils department, Michigan State University; C. S. Morrison, Deere and Co., Moline, Ill.; and W. V. Hukill, Agricultural Research Service, USDA, Iowa State College, Ames.

Pacific Coast Section

A MEETING of the Pacific Coast Section will be held in Tucson, Arizona, December 29 and 30. The tentative program includes papers on drainage, irrigation, corn and small seed harvesting, well drilling, vacuum cooling of vegetables, cotton mechanization, concrete pipe lines, concrete linings for trench silos, and grain-harvesting losses.

ASAE President Wayne H. Worthington will address the Section dinner on Thursday evening, December 29. A business meeting will be held in the afternoon of December 29 for election of new officers.

Southeast Section

THE Southeast Section will hold a meeting February 6 to 8, 1956, in Atlanta, Ga., in connection with the annual convention of the Association of Southern Agricultural Workers. The program will be announced later.

North Carolina Section

ABOUT 40 members of the North Carolina Section met September 9 and 10 at Morehead City. The theme of the meeting was the challenge to agricultural engineers of bringing organic soils into agricultural production. T. W. Edminster, Agricultural Research Service, U.S. Department of Agriculture, spoke on drainage in North Carolina that has been done and the job ahead. R. M. Williams, county agent of Carteret County, discussed the problem of salt in the soil brought about by recent flooding by hurricanes in his county.

The Saturday program consisted of a tour of the Open Grounds Farm in Carteret County, owned by Georgiana P. Yeatman. This farm consists of 43,000 acres, of which 2,200 acres have been cleared and seeded. Controlled drainage of this land was discussed by David S. Jones, U.S. Soil Conservation Service, and E. G. Diseker, North Carolina Agricultural Experiment Station. Other points of interest included demontrations of a soil tiller, a land leveler and a mole drain machine. The livestock enterprises were also visited on the tour. A lunch was served to the group by Miss Yeatman at her home.

Georgia Section

A MEETING of the Georgia Section was held at the Coastal Plain Experiment Station, Tifton, October 13 and 14. Registration began at 1:00 p.m. on Thursday. After a welcome to the station by F. P. King, resident director, the group enjoyed a tour of the station to observe and learn of latest research projects. At 6:00 p.m. an outdoor buffet dinner was held at the home of the Section Chairman James L. Shepherd. After the dinner a program on research projects conducted during the past few years at the experiment station was presented with colored film and slides by station engineers J. L. Shepherd and George N. Sparrow.

The second day consisted of a tour of the soil conservation station, a field trip to a farm reservoir and a trip to observe engineering phases of a conservation plan on crop land.

NECROLOGY

Dr. Robert W. Trullinger, a past-president of ASAE, and former assistant administrator for experiment stations (ARS), U.S. Department of Agriculture, who retired May 31, 1955, after 43 years of service, died Tuesday evening, November 8, at Doctors Hospital Washington, D. C., after a prolonged illness.

Dr. Trullinger was chief of the Office of Experiment Stations from 1946 until the reorganization of the U.S. Department of Agriculture in 1953, when his title was changed to assistant administrator for the Agricultural Research Service. He had responsibility for administration of the federal-grant funds for agricultural research at the state experiment stations, for federal territorial research, and for coordination of USDA research with that of the state experiment stations. He joined the Office of Experiment Stations in 1912 as specialist in rural engineering. A leading advocate of close cooperation between the states and the federal government in agricultural research, and between research and extension work for the improvement of the nation's agriculture, he was widely known at state land-grant colleges and universities throughout the country.

A native of Farragut, Iowa, Dr. Trullinger graduated from Iowa State College in 1910 with a B.S. degree in civil engineering. In 1925 he received the professional degree of agricultural engineer from the same institution. Rutgers University awarded him the honorary degree of doctor of engineering in 1941.

Dr. Trullinger was a World War I veteran, having served as research engineer officer, U.S. Army, part of the time overseas. He was a Life Fellow and a past-president of ASAE, and served for more than 20 years as member or chairman of the Society's research committee. From 1931 to 1936 he was active on the administrative board of the American Engineering Council. In 1941, the American Society of Agricultural Engineers awarded him the John Deere Medal. The Department of Agriculture presented Dr. Trullinger in 1953 with its Distinguished Service Award "for vision and leadership in research administration which has been a vital force in fostering strong federal-state relationships and in achieving an efficient, well-coordinated total agricultural research program." He was an honorary member of the Western Irrigation and Drainage Research Association and a member of Tau Beta Pi and Phi Kappa Phi honorary fraternities. He was a member of the U.S. Department of Agriculture American Legion Post No. 36 and a member of East Gate Masonic Lodge No. 34, Washington, D. C.

R. W. TRULLINGER

He is survived by his wife, a daughter and two grandsons. Internment was at Arlington Cemetery.

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Harley R. Kimmel, manager of general merchandise office (southern territory), Sears, Roebuck & Co., Atlanta, Ga., passed away in July. Mr. Kimmel joined the farm equipment department of Sears, Roebuck & Co. in 1939 and was active in setting up an agricultural engineering staff for the development of the company's line of farm equipment and supplies.

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Victor W. Thalmann, soil conservation engineer, Hawaiian Pineapple Co., Ltd., Lanai City, Lanai, T. H., died October 23. Mr. Thalmann joined the Society in 1936 when he was employed by the Soil Conservation Service in Fort Worth, Texas. He graduated from A. & M. College of Texas in 1928.

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H. W. Lindsay, works manager, Allis-Chalmers Mfg. Co., LaPorte Works, LaPorte, Ind., died October 17. He joined Allis-Chalmers in 1935 as manager of the grader department of the tractor division. He was made works manager of the LaPorte Works in 1942.

Minnesota Section

A MEETING of the Minnesota Section was held October 20 at the Minnesota Mining and Mfg. Co. central research laboratory —a three-million-dollar plant devoted entirely to research work. The evening program included talks by Vernon Meyer, agricultural engineering department, University of Minnesota, who spoke on application equipment for anhydrous ammonia, and by Willard Cockrane, U. of M. professor of agricultural economics, whose subject was on farm technological advances and surpluses.

Pennsylvania Section

HOWARD H. NUERNBERGER, Aluminum Co. of America, Pittsburgh, was elected chairman of the Pennsylvania Section at a meeting held at the Holiday Motor Hotel, Harrisburg October 20 and 21. Other new officers elected were Ralph E. Patterson, agricultural engineering department, Pennsylvania State University, as vice-chairman, and Joseph A. McCurdy, agricultural engineering extension, Pennsylvania State University, reelected as secretary-treasurer.

Attendence at the two-day meeting was 68 members and guests. The morning program for the first day was devoted to trends in farm buildings. Talks were given on such subjects as pole-type buildings, steel buildings, Hurricane Hazel damage, and painting galvanized roofing. In the afternoon papers were given on water resources, an irrigation guide, lighting in agriculture, and frozen-food cabinets. A tour of the Ralston-Purina feed-processing plant was made to observe the latest equipment and methods for handling and processing feeds. J. W. Frey of Franklin and Marshall College, Lancaster, gave an interesting and entertaining talk on Pennsylvania Dutch culture. The second day program consisted of an extension panel on forage handling.

Alabama Section

THE Alabama Section met October 21 and 22 on the campus of the Alabama Polytechnic Institute, Auburn. About 60 members and friends attended. The Auburn Student Branch attended both the formal program and the banquet on Friday night.

The program consisted of a series of tours of new facilities and equipment on the campus. The members toured the poultry farm of the college and were given an opportunity to observe feeding research and building research concerning outside brooding of chickens. A small commercial feed grinding and mixing mill was observed in operation at the next stop on the tour. This is one of several processing tests being conducted by the agricultural engineering department.

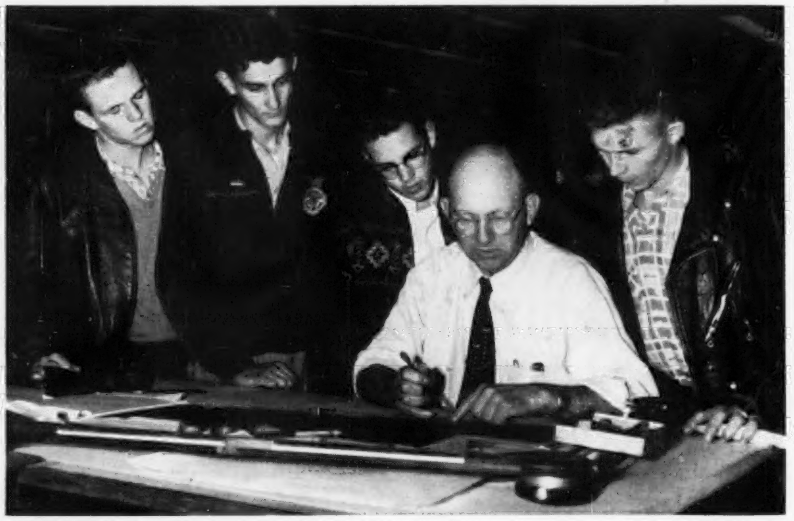
The college creamery was the third point visited during the Friday afternoon tour where equipment used in the handling of milk and milk products was observed. The next point of interest during the tour was the Auburn education television studio to see television in operation.

The Friday night program included a banquet and a talk on scientific photography by Reed Davis, USDA, Auburn. The Saturday morning program included a short business session and a tour of the engineering laboratory.

Quad City Section

ATTENDANCE at the meeting of the Quad City Section, November 4, in Moline, totaled 202 members and guests. The afternoon program was arranged for high school students from nearby towns as guests of the section. The student program consisted of a tour of the John Deere Harvester Works, East Moline, followed by a discussion of agricultural engineering education by Frank Lanham, head of the agricultural engineering department, University of Illinois, and Hobart Beresford, head of the agricultural engineering department, Iowa State College.

The regular program followed a dinner at the Tower in Moline. Murray W. Forth and Martin A. Berk, Deere and Co., presented a talk on automatic feed grinding on the farm. E. G. McKibben, chief, agricultural engineering research branch (ARS), U.S. Department of Agriculture, discussed and explained farm machinery research in the USDA.



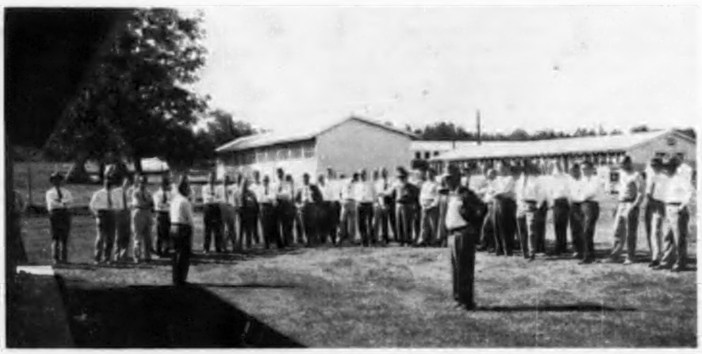
High school students were entertained by the Quad City Section at a section meeting held November 4. The program included a tour of the John Deere Harvester Works in East Moline. Getting some information first hand about what develops from the drafting board from Julius Kloepper, design engineer, are students *(Left to Right)* Larry McFarland of Moline High School; Gary Johnson, Prophetstown; Silas Teigland and Roy Sims, both of Moline High School.

Virginia Section

A MEETING of the Virginia Section was held at Roanoke Hotel, November 4 and 5. The first day's session was taken up largely with technical topics and other subjects of particular interest to the members. The day's session was highlighted by a talk given by H. W. Nicholls, branch manager, International Harvester Co., who told the group that the national farming and farm machinery situation are on a sound footing.

The second day of the meeting was given over entirely to the installation of officers and a discussion of plans for the 1956 ASAE Annual Meeting to be held at Roanoke Hotel, June 17-20. Installed as new section chairman was E. T. Swink, head, agricultural engineering, VPI, Blacksburg. Three new vice-chairmen are V. H. Baker, Guy W. Halsey and A. W. Cook. A. J. Lambert is the new secretary-treasurer. The nominating committee consists of U. F. Earp, McNeil Marshall and J. E. Reid.

Members of the Pennsylvania Section shown toured the Ralston-Purina feed processing plant to observe the latest equipment for handling and processing feeds.



The Alabama Section members listen to a discussion led by Dale King of the poultry department at API, Auburn. The tour was one of the high points of a section meeting held October 21 and 22.

Agricultural Engineering in Sweden

THE Swedish Institute of Agricultural Engineering is located at Ultuna on the campus of the Royal Agricultural College, a few miles south of Uppsala.

This is an institute for research and extension work in the field of farm mechanization, rural electrification and agricultural standardization. Its main purpose is to carry out fundamental experiments serving as a basis for new or improved design of farm implements and machinery and for work simplification.

In the year 1912 the Swedish Society of Motive Power in Agriculture was constituted in order to promote the use of tractors and electricity in agriculture. This society was reconstructed in 1927 into the Swedish Association of Agricultural Engineering. To finance its research program the association received an annual government grant.

Since, however, the resources were limited and the tasks expanding, the research and extension work was transferred to the Swedish Institute of Agricultural Engineering (Jordbrukstekniska institutet), which was established in 1945 by an agreement between the government and the Swedish Association of Agricultural Engineering. Two-thirds of the total expenditures of the institute are covered by government grants and one-fourth is paid by financial support from the farm machinery industry and from agricultural organizations. Further means are supplied by proceeds from the activities of the institute.

The institute is administered by a board of directors made up of a chairman and eight members. The government appoints the chairman and four of the members. Four members are appointed by the Swedish Association of Agricultural Engineering. The appointments are made for maximum terms of three years.

The director of the institute, Professor Nils Berglund (Member ASAE), is also head of the farm machinery institute of the Royal Agricultural College. The research leader, Yngve Andersson (Affiliate ASAE), specializes in equipment for silage-making. Two men are in charge of technical investigations and agricultural standardization, and one man works on problems regarding rural electrification. The staff also includes two men who are technical assistants and designers, two mechanics and seven office employees.

The work of the institute is carried out in accordance with its research program annually established by the board of directors. Special investigations are included in the research program on request of patrons.

The practical results obtained from investigations, field experiments and laboratory tests performed at the institute are published in two series, the one named meddelanden (bulletins) appearing in about eight issues a year, and the other cirkulär (circulars) appearing more irregularly. The bulletins are primarily intended to serve as manuals for the farmers.

The scientific results obtained from the research work of the institute and methods and instruments used are recorded in more extensive technical reports. These reports being of interest mainly to research workers and manufacturers are mimeographed and distributed in a limited number.

The members of the staff extend the experiences made in their work also by means of articles in farm papers and magazines, broadcasts, lectures, and last but not least by personal advisory.

The Swedish Institute of Agricultural Engineering is closely connected with the farm machinery institute of the Royal Agricultural College, which is in charge of the higher education in the farm machinery line. The coordination of the work is promoted by the fact that the two institutions are headed by one and the same director and are accommodated in the same building. In order to utilize their facilities better the two institutions have a joint office, a joint library, and often use instruments and laboratories in common as far as this arrangement does not interfere with the work of the one or the other.

It is the responsibility of the institute to assist in the teaching of agricultural engineering at the farm machinery institute.

Students at the agricultural college or at a college of mechanical engineering in Sweden or abroad, who are working for a degree or on special studies in this field of research, may be permitted to carry out investigations at the institute. Its facilities are made available to these research workers, unless the director considers such availability a drawback to the rest of the work at the institute.

The institute cooperates with several other scientific institutions in Sweden and also with the farm machinery factories, the electric industry, the tractor manufacturers, and organizations carrying on analytical and statistical work in the field of farm labor and economics, as well as with agricultural and technical extension centers in Sweden and abroad. A close collaboration is also maintained with the State Agricultural Machinery Testing Institute and with government agencies wanting the assistance of specialists on the staff of the institute.

The institute building shared with the farm machinery institute was completed in 1944 and consists of a two-floor office a one-floor laboratory, and a workshop. It occupies total floor area of 3200 square meters.

The equipment comprises power transformers, recording instruments, hardness and tensile strength measuring apparatus, traction meter, electric strain measurement equipment, drying oven, universal milling machine, electric drill and grinders, lathes, welding devices, compressor aggregates, motion picture cameras and projectors etc.

The Library of the institute comprises about 1200 volumes, 60 magazines and periodicals, and an extensive file of bulletins, catalogs and cuttings. The annual accessions of bulletins are considerable owing to exchange arrangements with several foreign libraries and research institutions.

List of Available Publications

Following is a list of publications available from the Swedish Association of Agricultural Engineering and the Swedish Institute of Agricultural Engineering. The publications are written in Swedish. The bulletins marked with an asterisk at the number have a summary in English.

*201 (1945) An investigation on machine-stations, by H. Lonnemark.

*202 (1946) Guide for contractors and machine associations, by H. Lonnemark.

*203 (1946) Swedish standards for spring-tooth harrows.

204 (1946) How to build silos for AIV-fodder, by Y. Andersson.

205 (1946) Making and feeding of AIV-fodder, by Y. Andersson and B. Grahn.

206 (1947) Care and adjustments of binders, by S. Alwerud and Y. Andersson.

208 (1947) The Use of Electricity in Swedish Agriculture. A report on an Agricultural Electric Survey, by H. A:son Moberg, O. Joachimsson and K. E. Hofvendahl. English translation in Circular No. 2.

*209 (1947) Instructions in the Use of Draining Plows, by E. Almlof and N. E. Ohlson.

210 (1947) Economic effects of research and technological progress in agriculture, by Dr. Eric Englund. English translation in Circular No. 1.

*211 (1947) Drying of combined grain, by Tore Lundstrom.

*213 (1948) Plough models from the 18th century exhibited at the Royal Agricultural College, Ultuna, Sweden. Studies of the collection of plough models of the Machinery Department, by R. Jirlow.

214 (1948) How to calculate cost and custom rates for machine operations in agriculture, by H. Lonnemark.

*215 (1948) Trench digging by universal excavator, by S. Persson and N. E. Ohlson.

*217 (1948) Farm Transport Blowers, by H. Gradin.

*218 (1948) Water pumps and pressure tank pumping systems, by S. Bjerninger.

*219 (1948) Farm transport vehicles. Concerning hitches for tractor-drawn four-wheeled wagons, by G. Aniansson and O. Noren.

*220 (1948) Swedish standards for farm transport blower piping, by S. Bjerninger.

*222 (1949) Tractor-drawn implement trailers for machinery stations and farms, by G. Aniansson and T. Andersson.

*223 (1949) Combining Grain at a low moisture content. An investigation of the moisture content of grain during the harvesting season 1948, by M. Berg and L. Ottosson.

*224 (1950) Pneumatic tyres for farm vehicles, by G. Aniansson and O. Noren.

*225 (1949) Influence of combining on the quality of grain, by M. Berg, L. Ottosson and E. Aberg.

*226 (1949) Some problems in the choice of crops and varieties by combining, by E. Akerberg and S. Halling.

*227 (1949) Trench digging by wheel type trenchers, by N. E. Ohlson.

228 (1949) Annual report 1948-49.

*229 (1950) Consideration of strength and durability in the design and dimensioning of farm wagons, by S. Bjerninger.

230 (1950) Problems in silage making, by F. Jarl, Y. Andersson and A. Haraldson.

*231 (1950) Laboratory investigations of farm wagons, by S. Bjerninger.

*232 (1950) Loading bags of combine harvested grain, by G. Aniansson, A. Haraldson and O. Noren.

233 (1950) Annual Report 1949-50.

*234 (1951) Tank system of combine harvesting, by G. Aniansson, O. Noren and A. Haraldson.

235 (1951) A guide to combine harvesting, by M. Berg and S. Persson.

236 (1951) Mechanised Agriculture in USA, by H. A:son Moberg.

237 (1951) Machine Milding, by I. Johansson, B. Eklundh, D. Carlsson and N. Lagerlof.

*238 (1951) Labour and machinery used in silage making, by Y. Andersson and A. Haraldson.

239 (1951) Annual Report 1950-51

240 (1952) Farm Transport and Conveying Equipment in USA, by S. Bjerninger,

*241 (1952) Tractors on small farms, by K. A. Svensson.

242 (1952) Electric motors on the farm, by R. Wilhelmson and T. Moller.

*243 (1952) Investigation on the usefulness of PTO-driven trailers for farm transports, by G. Aniansson.

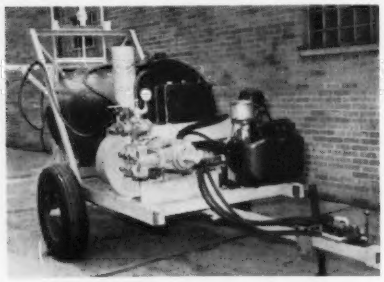
*244 (1952) Electric water heaters for dairy stables, by T. Moller and O. Noren.

245 (1953) Annual Report 1951-52.

246 (1953) I. Agricultural Population Decrease and Rationalization, by C. H. Nordlander. *(Continued on page 844)*

Asparagus Sprayer

O. W. Kromer Co., 1120 Emerson Ave., N., Minneapolis 11, Minn., has developed a special rig with a high pressure sprayer for spraying asparagus. The special Kromer sprayer carries its power with it, utilizing 12 hp to operate the spray pump and an additional 7 hp to activate the hydraulic pump. The sprayer hydraulically controls 32-ft booms that may be raised to a maximum of 6½-ft clearance, permitting them to clear fences at field edges. The spray pump develops up to 800 lb of pressure with an output of 20 gpm. Spray liquid is carried in a 300-gal tank, with full-length agitator, which is also power driven.



Power is supplied by a K660CS engine manufactured by Kohler Co., Kohler, Wis. Using gasoline for fuel, the engine develops 26.8 hp at full capacity of 3600 rpm. It is a 4-cycle, 2-cylinder opposed, L-head, air-cooled unit and has a fuel capacity of 10 gal. Standard equipment includes silencer muffler, automotive type fuel pump, oil bath air cleaner, oil pressure gauge and valve rotators. The model used on the Kromer sprayer is optionally equipped with clutch and electric starter and generator.

New 21-Foot Disk Harrow

Deere & Co., Moline, Ill., has introduced a new 21-ft disk harrow, the Model FW, a double-action, wheel-carried harrow for the new Model 80 Diesel tractor.

A hand crank enables the operator to level the harrow drawbar and adjust the cutting depth of the rear gangs. Once set for a particular tractor, this adjustment need not be made again. The remaining adjustments are on the spring-pressure rods (one on each side) which make the rear extension gangs work deeper or shallower at the outer ends as desired.

In the field, the harrow is said to level itself automatically by means of a heavy-duty coil spring. Another spring absorbs shocks while the harrow is in transport position. One man can swing the end gangs around and reduce the over-all width to less than 15 ft for transporting in a few minutes and without the use of tools. Raising and lowering the harrow and setting working depth are controlled through the tractor hydraulic system.

NEW PRODUCTS CATALOGS

Power Steering Bulletin

Vickers Incorporated, 1400 Oakman Blvd., Detroit 32, Mich., has released a new 2-page, 8½ x 11, 2-color bulletin (No. M-5107) describing the new series S22 power steering booster for small vehicles. The new bulletin discusses the design, construction and maintenance features of the new booster and includes application and ordering information. Recommended pump and reservoir equipment for use with the S22 booster are also described. Typical steering pump performance curves are included. Diagrams show steering circuits with or without an integral oil reservoir.

Direct-Reading Hour Meter

John W. Hobbs Corp., Division of Stewart-Warner Corp., Springfield, Ill., has announced a new direct-reading engine hour meter, which rounds out their meter production, long identified with pointer-type models. The new meter is read in much the same way as the odometer in the speedometer of an automobile. Black figures show the total number of hours an engine has been operating; the red figure at the right indicates tenths of hours. A rotating disk in the upper left segment of the face

of the meter acts as an operating indicator, making one revolution a minute. This feature shows that the meter is operating. The meter is available in 6, 12, 24, 32, 64 and 110-v models in three basic types: standard (mounted with 3 screws); flush-mounting (held in place by a stirrup, no screws required), and aircraft (standard aircraft installation).

New Land Leveler

Gurries Mfg. Co., San Jose, Calif., has introduced a new 50-ft land plane with a 10 or 12-ft bowl. This new leveler features an automatic hydraulic leveling method which holds the machine and rigid blade on a straight line from front to rear. The

carrier wheels are said to automatically raise and lower to follow the contour of the ground while the bowl is held level. The GP-50 can be collapsed to a transport length of 30 ft 8 in. Approximate capacity of the unit with the 10-ft bowl is 3⅓ cu yd, and for the 12-ft bowl, 4 cu yd.

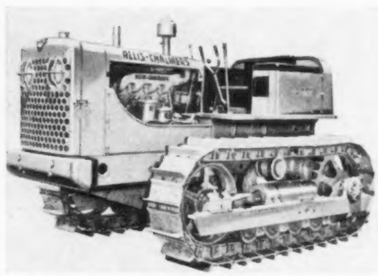
Torsion Frame Disk Harrow

International Harvester Co., 180 N. Michigan Ave., Chicago 1, Ill., has announced a design feature in its new No. 37 wheel-controlled disk harrow that lets any gang ride over high spots or rocks without lifting the other gangs out of the ground. The high-strength steel used in the torsion-built frame can twist to give each gang independent knee action. When a gang hits an obstruction or hard spot, it rides over. The harrow remains level, holding the other three gangs in the ground.

One-minute gang angling and easy settings, to eliminate center ridging at fast speeds, and hydraulic raising and lowering of gangs are also featured in the new disk harrow. The new tool is available in sizes up to 14 ft.

57-HP Diesel Crawler

Allis-Chalmers Mfg. Co., Milwaukee, Wis., has announced its new diesel-powered, 12,400-lb, HD-6 crawler tractor. Features include a new diesel engine; an all-steel-box type A main frame; straddle-mounted double reduction final drive gears mounted on tapered roller bearings; roller bearing truck wheels with 1000-hr lubrication; hardened tracks, and ceramic master clutch lining.



The new power train is the A-C HD-344 diesel engine, a 4-cylinder, 4-cycle unit that is said to develop 57 net flywheel horsepower, 45 hp at drawbar and 55 hp at the belt. The maximum drawbar pull is approximately 12,650 lb. It has five forward speeds ranging from 1.5 mph in first to 5.5 mph in fifth gear, and 2 mph in reverse. A 24-v electric starting and lighting system is standard.

Barn Cleaner Catalog

Clay Equipment Corp., Cedar Falls, Iowa, has issued a new 16-page barn cleaner catalog. Illustrations show a range of cleaners from large, heavy-duty models, designed for the largest dairy operations, to the new cable cleaner designed for installation in single-gutter barns. Detailed drawings show possible cleaner arrangements and spreader locations for different types of barns. Questions and answers about size of cleaner, size of motor, size of drive unit for your farm, correct paddle spacing and choosing the right chain are included.

(Continued on page 830)

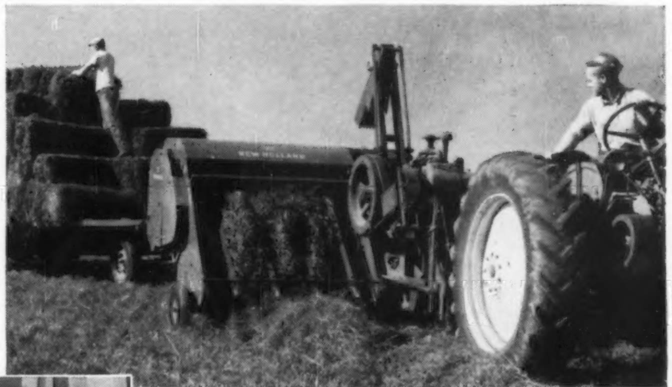
BCA PLUNGER ROLLER BEARINGS

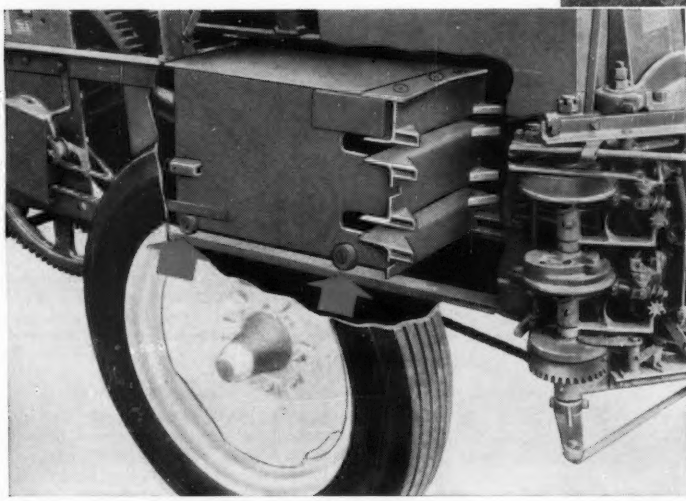
give "smoother, more efficient operation"

on New Holland Super "77" Automatic Baler

New Holland Machine Company, Engineering Division, reports on BCA *package unit* bearings:

1. **Effective sealing**—proved in laboratory tests and under extremely dusty field conditions.
2. **Convenience**—sealed bearing, outer shoe, and mounting stud are all built into one compact unit.
3. **Long life in the field.**
4. **Low rate of wear**—maintain close plunger knife adjustment.
5. **Save power**—low friction results in an easy rolling plunger.





Cutaway view shows how BCA plunger roller bearings are designed into baler. Package units are built with thick-section outer ring, hardened throughout, specially adapted for rolling heavy masses on rails. Available with crowned or V-groove OD.

In this automatic pick-up baler, the plunger runs on BCA sealed, pre-lubricated ball bearings. This means fewer adjustments; lower maintenance costs; and smoother, more efficient operation for the farmer. *Package units* of sealed bearing, outer shoe, and mounting stud speed up and simplify assembly for the manufacturer.

If you have a bearing problem, BCA engineering cooperation and design assistance will provide the positive solution.

If you've got a bearing problem, contact:

BCA

BEARINGS COMPANY OF AMERICA

DIVISION OF FEDERAL-MOGUL CORPORATION

LANCASTER • PENNSYLVANIA

Pioneers of pre-lubricated *package unit* ball bearings for agriculture

New Products and Catalogs

(Continued from page 828)

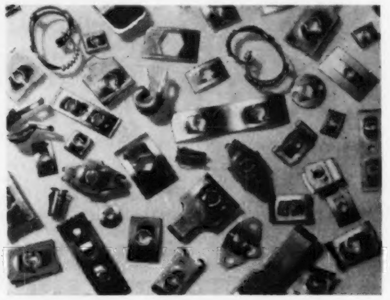
Flexible-Shaft Post Hole Digger

The Stow Manufacturing Co., 39 Shear St., Binghamton, N. Y., has designed a new type flexible shaft especially for a new post hole digger. This flexible shaft has a core ½ in diam made of music wire. The flexible casing is lined with oil-resistant spring steel reinforced with wire braid, and covered with oil-resistant neoprene-impregnated fabric, and an abrasion-resistant rubber jacket.

By using the flexible shaft, the weight of the engine can be carried on the operator's back. A small worm gear box at the drill reduces the engine speed to the necessary drilling speed.

Spring-Tension Fasteners

Tinnerman Products, Inc., Box 6688, Cleveland 1, Ohio, has announced the latest additions to its increasing line of spring-tension, Speed Nut brand, fasteners. The fasteners are especially designed for hard-to-

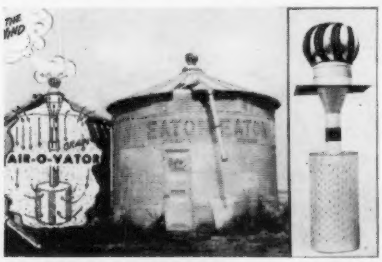


get-at places, but the large variety comprising over 8,000 shapes and sizes provides a suitable fastener for almost any fastening or clamping job.

A 46-page catalog, available from the manufacturer, contains illustrations of many of the various types and shows typical applications. The accompanying illustration shows only a few of the many available types.

Wind Power Grain Aerator

Air-O-Vator Co., PO Box 697, Scottsbluff, Nebr., has announced a new device for utilizing wind power in drawing air through grain. The unit moves the air in



accordance with three principles of air movement: (a) the exhaust spinner-head, which sets on the roof of the bin, will turn in a 1-mph breeze or will exhaust without any breeze, if there is a temperature differential; (b) when the spinner removes air from the vacuum tank, new air takes its place in this partial vacuum — the air goes through the grain pile, into the vacuum tank and out through the spinner, and (c) for an increase of temperature differential between the heated air in the grain pile and the outside air, the unit increases its efficiency.

Neoprene Impeller Pumps

American Machine Products, Inc., 172 Centre St., New York 13, N.Y., has introduced a new series of Neoprene rubber impeller pumps from ⅜ to 1¼-in ips (iron pipe size) with flow ranges to 55 gpm. The new pumps are designed to transfer any liquid that does not affect bronze or Neoprene, with pressure range to 30 psi, depending upon model. Pumps operate in

either direction at low or high speeds. The impeller is replaceable and is keyed to the shaft for easy application. The pump itself is made entirely of bearing bronze, while the shaft is stainless steel. It will pass small particles of foreign matter and abrasives.

The unit is self-priming to about 15 to 20 ft. Speeds range from 100 rpm to a maximum of 1750 rpm.

Dragline for PTO Grinder

The Letz Mfg. Co., Crown Point, Ind., has announced a new 10-ft dragline extension for its PTO feed grinders.

The illustration shows the new dragline mounted upon the mill feeder and driven by the mill feeder shaft. In the tunnel, un-

der the corn crib, is the 10-ft extension of the dragline. For use in corn crib or granary driveways, the dragline is also available with flaring sideboards. To attach and operate the new dragline, the three-sided hopper is removed from the bottom of the mill feeder and the front end of the dragline is bolted in place.

Rotary Hoe Attachments

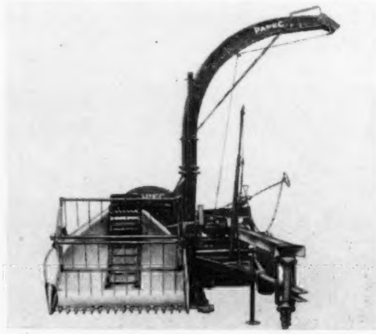
International Harvester Co., 180 N. Michigan Ave., Chicago 1, Ill., has announced production of rotary hoe attachments available for its line of McCormick cultivators. Rotary hoe cultivation is said to permit higher speeds during first cultivation because the hoe teeth break the soil crust and kick

out small weeds in the row without harming the young plants.

The rotary hoe attachments replace the regular shields, and the regular cultivator gangs sweep the weeds out between the rows. Attachments are available for all McCormick cultivators used in cotton, peas and beans.

PTO Forage Harvester

Papec Machine Co., Shortsville, N. Y., has announced its new No. 32 forage harvester designed primarily to be used by farmers with small herds. The unit features 98 sq in of throat opening and a flywheel speed of 828 rpm when operated at



standard PTO speed. Other features include two quick-change attachments, adjustable axles, side and rear feed delivery, large range of cut, and straight easy-to-sharpen knives.

Dual-Chamber Relief Valve

Delavan Mfg. Co., West Des Moines, Iowa, has announced the addition of a new pressure-relief valve especially designed to handle highly corrosive agricultural chemicals.

The new valve features dual-chamber construction which separates the flow of chemicals from the regulating mechanism when the valve is in operation. The company

says the new valve has sufficient capacity to by-pass the full flow of a ¾-in supply line under normal operating pressures. It is available in ½ and ¾-in inlet sizes.

(Continued on page 836)

ENGINEERING IN ACTION

makes the difference in earning power

Until recently a farm tractor at work was simply a combination of weight and power in motion—with pulling capacity and earning power largely dependent upon the amount of weight carried on the drive wheels.

Today, the work capacity of Allis-Chalmers tractors, and the return from a farmer's investment, is measured by a new concept . . . *engineering in action!*

For example, the Allis-Chalmers WD-45 Tractor does not depend upon its own weight alone for adequate traction to utilize the full power of its dynamic engine. By means of the exclusive hydraulic Traction Booster, it *automatically* transfers to the drive wheels as much of the implement's weight as needed, to assure ground-gripping traction and reduce power-wasting slippage to a minimum.

The Allis-Chalmers Traction Booster system of weight transference eliminates the need for costly, useless weight in the tractor. Implement weight becomes working weight, applied and removed as needed. The action is as automatic as that of an engine's governor.

More performance with less weight . . . at lower cost to the purchaser . . . that's Allis-Chalmers engineering in action.

Today, it makes an important difference in the return a farmer can expect from his tractor investment.

FARM EQUIPMENT DIVISION, MILWAUKEE 1, WISCONSIN

ALLIS-CHALMERS

International Harvester Company Farmall Cub Tractor does a discing job—one of its many round-the-clock tasks.

To make a tractor engine run better longer ...*specify* PUROLATOR

On farms throughout the country, a tractor is an economic necessity.

From dawn to dusk—often on through the night—today's "steel horses" keep hard at it—often in fields clouded with dust.

A breakdown, a few hours' delay—at planting or harvesting time—can seriously affect the farmer's entire year's profits.

Tractor makers know this! That is why they give top attention to lubrication systems; why efficient oil filtration is a "must" in today's tractor engine design.

PurOlator

America's No.1 **OIL FILTER**

5 reasons why more major tractor manufacturers specify Purolator-built filters and refills than any other make

1. Purolator's famous "accordion-pleated" Micronic filter element has *up to ten times more filtering area than ordinary types.*

2. Electron micro-photographs prove that Purolator Micronic filters stop harmful particles microscopically small from reaching delicate engine parts.

3. The pleated design of the Purolator Micronic filter element provides *many times more dirt storage space than old-style filters.*

4. With its larger filtering area, the Purolator Micronic filter element introduces a remarkably small pressure drop into the lubricating system . . . *permitting pumps of practical size and simple type.*

5. With Purolator Micronic Filtration, the tractor operator keeps all the oil quality he pays for. *The Micronic filter element will not strip additives ...an important advantage with H.D. and heat-resistant oils.*

For further information write, wire or phone:
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Rahway, New Jersey and Toronto, Ontario, Canada.
Factory Branch Offices: Chicago, Detroit, Los Angeles

"Purolator," "Micronic," Reg. U. S. Pat. Off.

New Products and Catalogs

(Continued from page 830)

Improved Clutch

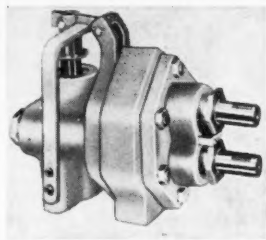
The Rockford Clutch Division of Borg-Warner Corp., 1301 18th Ave., Rockford, Ill., has developed a new type clutch designed specifically for heavy-duty service. The new clutches are offered under the trademark name of Morlife.

Rockford engineers state that field tests show that the new clutches provide up to 100 percent more torque capacity than previous models and permit the use of smaller diameter, less expensive clutches. Also less lever or pedal pressure is required for engaging and disengaging.

The work life is said to have been increased as much as four times and heat dissipation has been improved to the extent that excessively burned or warped clutch plates have been eliminated. It is reported that torque does not fade as heat increases.

3-Way Valve and Pump

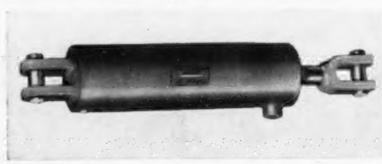
Wisconsin Hydraulics, Inc., 3165 North 30 St., Milwaukee 16, Wis., announces a new, spool-type, 3-way valve and pump combination designed for use with single-acting hydraulic cylinders. The spool-type valve can be operated by cable or lever control for raise, hold and lower positions.



The new SL series is rated for 1000-psi duty and tested at 2000-psi overload and 3000-psi shock load. A built-in, adjustable pressure relief valve is used. Units are available in five sizes, developing from 8 to 22 gpm at 1000 rpm and 1000 psi. Single or double-shaft models are available.

Hydraulic Cylinders

Modernair Corp., 400 Preda St., San Leandro, Calif., has introduced a new line of high-pressure hydraulic cylinders designed specifically for use on farm equipment and tractor-operated implements.

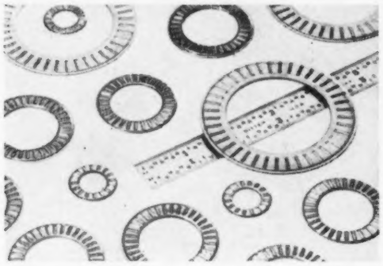


The series F cylinders are built to ASAE standards, with 20¼-in distance between pin centers in all sizes up to 10-in stroke length. Features include O-ring seals throughout; ground and polished chrome-plated steel shaft with wiper seal; seamless steel barrel, and aluminum-alloy front head and piston. Rear head is machined from solid steel bar stock, with separately welded rear clevis tongues.

Stock sizes include 8 and 10-in stroke lengths in 2, 2½ and 3-in-bore sizes, for operation at 1500 psi. Infinitely adjustable mechanical stroke control is available. Special types and sizes can be supplied on order.

New Needle Thrust Bearing

The Torrington Co., Torrington, Conn., has announced addition of the new NTA series needle thrust bearing to its line. The new bearings can be used in combination with bearings designed for radial loads where each type of loading exists.



Initial production will include four sizes: $\frac{1}{2}$-in bore by $\frac{15}{16}$-in outer diameter; $\frac{3}{4}$-in by $1\frac{1}{4}$-in; 1-in by $1\frac{9}{16}$-in; and $1\frac{1}{4}$-in by $1\frac{15}{16}$-in. Bearing bores are designed for a running fit on standard shafts.

Outside diameters are 0.010 in under nominal. The cross section, or roller diameter, is 0.078 in. The new bearing uses two mating retainer halves which are steel stampings joined securely by spinning to effect a self-contained unit closed both on the outer and inner diameters. The flange construction closing the outer diameter stiffens the assembly and is said to help maintain dimensional stability during heat treatment.

New Swaged Hose Catalog

The Weatherhead Co., Fort Wayne Div., 128 W. Washington Blvd., Fort Wayne, Ind., has released a new 8-page, 2-color swaged hose assembly catalog which shows the complete line of Weatherhead swaged hose, hose ends and adapters.

Also featured in Catalog S-1 is a simple, detailed swaged hose assembly numbering system. Hose assemblies of any size, type, length, pressure and quantity can be ordered.

Hydra-Creeper for Farmall 100

International Harvester Co., 180 N. Michigan Ave., Chicago, Ill., is now offering its Hydra-Creeper attachment for the Farmall 100 tractor. The attachment, previously available only for the Farmall 200, provides four creeper speeds, ranging from $\frac{1}{5}$ to 1 mph at full power. It is used primarily for transplanting vegetables, tobacco, flowers and nursery stock, for planting flower bulbs, and for special harvesting jobs where slow speeds are essential.

The attachment consists of a hydraulic motor driving a chain and sprocket speed reducer. Hydraulic power is supplied by the tractor's engine-mounted pump. Power is transmitted through the PTO shaft to the tractor's regular transmission. The unit is easy to attach or detach and does not interfere with the use of regular equipment at normal tractor speeds.

NEW BOOKS

Introduction to Agricultural Engineering, by H. F. McColly and J. W. Martin. Cloth, x + 553 pages, 6 x 9 inches. Illustrated and indexed. McGraw-Hill Book Co., Inc., 330 West 42nd St., New York 36, N. Y. $7.50.

The book has been written primarily as a text for first-year students as an introduction to the professional agricultural engineering curriculum. It also provides a practical and technical background in various areas of specialized study which should be of interest to any person in the agricultural engineering field. The book has been divided into eight parts, as follows: engineering in agriculture, agricultural mechanics, farm power, farm machinery, rural electrification, processing agricultural products, farm structures and conveniences, and soil-and-water-conservation engineering.

The material presented in this book should provide an agricultural engineering student with a cross section of his chosen profession, sufficient to prevent him losing sight of his goal during the seemingly never-ending period of basic courses.

Principles of Farm Machinery, by Roy Bainer, R. A. Kepner and E. L. Barger. Cloth, xi + 571 pages 5½ x 8½ inches. Illustrated and indexed. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y. $8.75.

This is the fifth book, the third in the past year, to be published in the Ferguson Foundation Agricultural Engineering Series of texts. The book is written primarily as a text for the upper-division course in farm machinery with emphasis on the functional requirements of the basic types of field machinery and their principles of operation. Chapters cover the more common types of machines and also a general discussion of materials, power transmission, economics and methods for testing and evaluating performance.

Digest of Proceedings of 1955 Industry-Research Conference held April 4 to 6, 1955, at Urbana, Ill. The conference was devoted to research related to the farm equipment industry and sponsored by the agricultural engineering department, University of Illinois and the Farm Equipment Institute.

The 56-page booklet contains a resume of each of the papers presented during the conference as well as several interesting photographs. Also included is a list of projects representing work being done by state agricultural experiment stations that is of interest to those who are associated with the farm equipment industry. Copies are available from the Farm Equipment Institute, 608 S. Dearborn St., Chicago 5, Ill. Price 50 cents.

Forestry Handbook, by Reginald D. Forbes for the Society of American Foresters. Cloth, xi + 1193 pages, 6 x 9 inches. Illustrated and indexed. The Ronald Press Co., 15 E. 26th St., New York 10, N.Y. $15.00.

Sections cover aerial photography, chemical and physical tables and definitions, chemistry and physics of wood, communications, cutting budget and annual cut, economics and finance, fires, geology and soils, insects and diseases, logging, materials, structures, facilities, mathematical formulas and definitions, forest measurements, range management, recreation, road engineering, silvics and silviculture, surveying, utilization and wood technology, volume tables, watershed and wildlife management, yield tables and stocking.

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Abernathy, George H. — Junior research specialist in agricultural engineering, University of California, Davis, Calif. (Mail) Apt. 11, 118 C St.

Anderson, Karl C.—Junior engineer, John Deere Waterloo Tractor Works. (Mail) 1718 Maplewood Dr., Cedar Falls, Iowa.

Bailey, Glenn R.—Assistant engineer, nitrogen equipment dept., General Metals, Inc., PO Box 448, Greensboro, N. C.

Baird, E. Douglas—Farm advisor, agricultural extension service, University of California, 808 N. Spring St., Los Angeles, Calif.

Balis, John S.—Instructor in agricultural engineering, Purdue University, Lafayette, Ind.

Bane, John D. — Instructor in agricultural engineering, West Virginia University, Morgantown, W. Va. (Mail) 335½ Beverly Ave.

Bessant, Leonard S. — Irrigation engineer, Food Machinery & Chemical Corp., Florida Div. (Mail) PO Box 1024, Plant City, Fla.

Brosz, Donald J.—Assistant in agricultural engineering, South Dakota State College, College Station, Brookings, S. D.

Cadagan, Dan J. —Sales engineer, Miller-Poston Mfg. Co., Spokane, Wash. (Mail) 3002 S. Manito.

Cohron, Gerald T. — Engineering trainee, Caterpillar Tractor Co., Peoria, Ill. (Mail) Manias Manor, Apt. B, 101 E. Pennsylvania.

Doerr, Edward C.—On duty with U.S.M.C. (Mail) 81A Purvis Dr., Triangle, Va.

Dunkel, Arthur D. — Agricultural engineer (SCS), USDA. (Mail) PO Box 307, Visalia, Calif.

Earle, Jr. Courval P. — Assistant to sales manager, Shur-Rane Dept., John Bean Div., Food Machinery & Chemical Corp., Lansing, Mich.

Grinnell, Robin R.—Assistant in agricultural engineering, University of Illinois, Urbana, Ill. (Mail) Room 307, Agricultural Engineering Bldg.

Halderman, Allan D. — Research engineer, Irrigation Equipment Co., Long Valley, N. J.

Higginbotham, Nathan L. — Engineering trainee, General Electric Co. (Mail) RR 4, Amherst, Va.

Hilyer, William A.—Student in agricultural engineering, Alabama Polytechnic Institute. (Mail) Box 163, East Tallassee, Ala.

Hixon, Owen P. — On duty with U.S.A. (Mail) Box 272, Manzanola, Colo.

Hock, Owen W. — Special representative, sales development div., Caterpillar Tractor Co., Peoria, Ill.

Jayasinghe, Anton C. — Works engineer, agricultural engineering div., Brown & Co., Ltd. (Mail) 426 Gansabawa Rd., Nugegoda, Colombo, Ceylon.

Johnson, Jr., William M. — Farm service engineer, Kentucky Utilities Co., Lexington, Ky. (Mail) RR 4, Bryan Station Rd.

Kammer, Charles H.—Junior engineer, engineering dept., Standard Fruit Co., La Ceiba, Honduras, C. A.

(Continued on page 842)

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Milling is done by highly skilled men, using modern precision equipment.

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These quality features contribute much to structural strength and stability, reduction of waste, and true building economy. Agricultural engineers see in Weyerhaeuser 4-Square kiln-dried lumber extra building values for farmers.

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Weyerhaeuser 4-Square

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Applicants for Membership

(Continued from page 840)

Karim, Mansour—Student in agricultural engineering, South Dakota State College, Brookings, S. D. (Mail) 802 11th Ave.

Kessler, Kenneth Q.—Student engineer, John Deere Ottumwa Works, Ottumwa, Iowa. (Mail) 2316 N. Court.

Kinser, Dick R. — Floor salesman, Southern Equipment & Tractor Co. (Mail) 1234 Leighton Dr., Baton Rouge, La.

Koger, Wm. H. — Production engineer, Armco Drainage & Metal Products, Inc., Middletown, Ohio. (Mail) 1027½ Hughes St.

Konrad, Dwayne E.—Student in agricultural engineering, South Dakota State College. (Mail) Tripp, S. D.

Korte, Leland E. — Engineering trainee, John Deere Waterloo Tractor Works, Waterloo, Iowa. (Mail) 318 Sunnyside.

Lim, Edward A. — Postgraduate student in electrical engineering, University of Wisconsin. (Mail) 240 Langdon St., Madison 3, Wis.

Locker, James P.—Irrigation sales engineer, Schuell Supply Corp. (Mail) Box 93, Bourbon, Ind.

Lucke, Virgil H. — Graduate student in mechanical engineering, Ohio State University. (Mail) 2354 Indiana Ave., Columbus 2, Ohio.

McGown, John E. — Special representative, sales development div., Caterpillar Tractor Co., Peoria, Ill.

Middleton, James E. — Specialist in irrigation, agricultural extension service, University of Arizona, Tucson, Ariz.

Molyneux, William E. — Farmer, Box 11, Cloverdale, B. C., Canada.

Musial, Paul — Instructor and fieldman in agricultural machinery, Western Ontario Agricultural School, Ridgetown, Ont., Canada.

Neff, Lyle W. — President and manager, Agriform Co. of Washington. (Mail) 903 Octave, Pasco, Wash.

Nelson, Roger J. — Engineering trainee, John Deere Waterloo Tractor Works, Waterloo, Iowa. (Mail) 247 Madison St.

Olson, Robert R. — Junior engineer, engineering research div., John Deere Waterloo Tractor Works, Waterloo, Iowa. (Mail) 1021 W. Mullan.

Polzin, Donald H.—Engineer trainee, John Deere Waterloo Tractor Works, Waterloo, Iowa. (Mail) 600 Marsh St.

Potter, Jimmie C.—Junior engineer, John Deere Waterloo Tractor Works. (Mail) 3006 Loma, Cedar Falls, Iowa.

Puryear, David B.—Graduate fellow in agricultural engineering, Purdue University, Lafayette, Ind.

Ross, Ira J.—Graduate student in agricultural engineering, Purdue University, West Lafayette, Ind.

Schultz, Alfred F. — Special representative, Illinois Power Co., 134 E. Main St., Decatur, Ill.

Seferovich, George H. — Editor and vice-president, Implement & Tractor Publications, Inc., 601 Graphic Arts Bldg., Kansas City 5, Mo.

Shindelar, Joseph J.—Engineer, John Deere Des Moines Works. (Mail) 412 E. 2nd St., Ames, Iowa.

Smith, Richard W. — Sales representative, Fafnir Bearing Co., 1907 7th Ave., Moline, Ill.

Stewart, Donald P. — Agricultural engineer (SCS), USDA. (Mail) PO Box 727, Shoshone, Ida.

Suter, Dwayne A. — Graduate assistant in agricultural engineering, Oklahoma A. & M. College, Stillwater, Okla.

Termont, Charles G. — Design engineer, John Deere Spreader Works, East Moline, Ill.

Thaden, T. J.—Agricultural tire design engineer, agricultural tire development dept., Goodyear Tire & Rubber Co., 1144 E. Market St., Akron 16, Ohio

Thompson, Robert W.—Agricultural engineer (AMS), USDA. (Mail) Purdue University, Lafayette, Ind.

Tilson, Jr., Bryson H. — Electrification advisor, French Broad Electric Membership Corp. (Mail) Box 584, Mars Hill, N. C.

Togami, Paul G. — Design engineer, East Moline Works, International Harvester Co. (Mail) 1183 26th St. A, Moline, Ill.

Tolen, Howard R. — Market research div., J. I. Case Co., 700 State St., Racine, Wis.

Tuttle, Winn F. — Farm service consultant, Puget Sound Power & Light Co., Bellingham, Wash. (Mail) 1469 Pacific Hiway.

Upshur, Charles T. — Owner and manager, The C. T. Upshur Co., PO Box 106, Leland, Miss.

Wendell, Philip F.—Chief engineer and designer, American Planter Co., Burr Oak, Mich. (Mail) Box 789

Wolfe, Paul E.—Design engineer, Massey-Harris-Ferguson, Inc. (Mail) 1527 Larkmoor Blvd., Berkley, Mich.

Yost, Gilbert E. — Agricultural engineer (AMS), USDA. (Mail) Box 113, East Grand Forks, Minn.

(Continued on page 844)


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Applicants for Membership

(*Continued from page 842*)

Young, Harvey G. — Instructor in agricultural engineering, South Dakota State College, Brookings, S. D. (Mail) East Side Trailer Park.

Transfer of Membership

Bartlett, A. B. — Western regional service manager, Ferguson Div., Massey-Harris-Ferguson, Inc. (Mail) 161 Hazel Dr., Pleasant Hill, Calif. (Associate Member to Member)

Colbenson, Paul D. — Research engineer, Douglas Fir Plywood Assn., 1214 A St., Tacoma, Wash. (Associate Member to Member)

Ghosh, B. N.—Postgraduate student in agricultural engineering, King's College, Newcastle-on-Tyne 2, England. (Associate Member to Member)

Grub, Walter—Associate agricultural engineer, Alabama Polytechnic Institute, Auburn, Ala. (Associate Member to Member)

Hanford, William D.—Assistant editor, *Farm Implement News.* (Mail) 4601 Washington St., Downers Grove, Ill. (Associate Member to Member)

Hofmeister, Jr., Harry J. — Sales engineer, Delco Products Div., G.M.C. (Mail) 2535 Acorn Ave., N.E., Atlanta, Ga. (Associate Member to Member)

McCreery, William F.—Agricultural engineer, Tillage Machinery Laboratory, USDA. (Mail) PO Box 792, Auburn, Ala. (Associate Member to Member)

McDougall, Wallace — Field test engineer, engineering dept., New Idea Div., Avco Manufacturing Co., Coldwater, Ohio. (Affiliate to Associate Member)

Webster, J. Vincent — Project engineer, David Bradley Mfg. Works. (Mail) 439 S. Lincoln Ave., Kankakee, Ill. (Associate Member to Member)

Agricultural Engineering in Sweden

(*Continued from page 827*)

II. Machinery Development-Trends in Sweden and Abroad, by H. A:son Moberg. (Papers given at the Annual Meeting of the Swedish Assn. of Agr. Engineering, 31.7.1953.)

*247 (1953) Methods for determining moisture content and for sampling in granaries by B. Nystrom.

248 (1953) Offer forms for electric installations on farms, by T. Moller.

*249 (1953) Braking equipment for farm tractors and trailers, by S. Bjerninger and A. Pettersson.

*250 (1953) Mechanical tile drain installation.

*251 (1953) Calculation of costs and price rates for machine work in agriculture, by H. Lonnemark.

252 (1953) Annual report 1952-53.

253 (1954) Fitting and maintenance of farm trailer brake system, by A. Pettersson.

*254 (1954) Labour used in silage making on middle-sized and small farms, by Y. Andersson.

255 (1954) Wheels, roller-bearing hubs and axles for farm trailers, by S. Bjerninger.

256 (1954) Growing and harvesting peas, by Y. Andersson & E. Akerberg.

*257 (1954) Feed Trucks with Rubber Tires, by S. Bjerninger.

258 (1955) Annual Report 1953-54.

*259 (1955) Engine power utilized and fuel consumption during different tractor operations, by G. Jeppsson

*260 (1955) A study on tractor work on small farms, by N. Berglund & B. Karlson.

*261 (1955) Diesel tractor maintenance, by A. Ekelof.

*262 (1955) Grain drying by H. Gradin & B. Nystrom.

NEW BULLETINS

Carton Filler for Food Processing Plants by Harold D. White. Georgia Agricultural Experiment Stations, University of Georgia College of Agriculture (Athens) Circular N.S. 2, (August 1955). The 8-page, illustrated folder describes and contains plans for a vibrator type carton filler. The carton filler was developed to increase production and to relieve the tedium of filling cartons by hand. With it, one person, it is reported, can fill 5,000 10-oz cartons of field peas, lima beans, garden peas, or cut beans a day.

How to Select and Use Concrete Blocks in Farm Buildings by E. S. Holmes. University of Kentucky Circular 434 (revised). The 12-page bulletin describes the types of blocks, quality of blocks, how to lay a wall, treating weather-exposed walls, and construction details involved in the use of concrete blocks for farm buildings.

Engineering Aspects of Close-Row Peanut Production, by Buford M. Cannon. North Carolina Agricultural Experiment Station (Raleigh) Information Circular No. 11 (July, 1955). The 16-page circular contains results of work being done to determine the adaptability of existing planting and cultivating equipment to peanuts in close rows using both 3 and 4-wheel tractors without changing their wheelbase.

(*Continued on page 846*)

NEW BULLETINS

(Continued from page 844)

Effectiveness of Hammer-Driven Screw-tite Masonry Nails in Concrete, by E. George Stern. Virginia Polytechnic Institute Wood Research Laboratory, (Blacksburg), Bulletin No. 20 (September, 1955). The 16-page bulletin is divided into two parts, one part devoted to light nails and the other to heavy duty nails.

NIAE Bulletins. The following bulletins have been received recently from the National Institute of Agricultural Engineering, Wrest Park, Silsoe, Bedfordshire, England.

Loads on a Tractor Lift Carrying a 3-Furrow Mounted Plough—Technical Memorandum No. 112.

The Production of Hay on Racks and Tripods—Report No. 53.

PERSONNEL SERVICE BULLETIN

NOTE: In this bulletin the following listings current and previously reported are not repeated in detail; for further information see the issue of AGRICULTURAL ENGINEERING indicated.

POSITIONS OPEN — JUNE—O-248-733. O-307-739, 316-740. AUGUST — O-305-741, 325-743, 324-745, 334-746, 338-747, 345-748, 346-749, 346-750, 347-751, 350-752. SEPTEMBER—O-331-754, 363-755, 335-756, 352-758, 372-759, 384-760. OCTOBER—O-401-761, 402-762, 402-763, 404-764, 405-765, 409-766, 409-767, 409-768, 407-769, 407-770, 407-771, 413-772, 415-773, 394-774. NOVEMBER—O-385-775, 430-776, 439-777, 446-778, 451-779, 453-780, 453-781, 454-782, 448-783, 463-784, 463-785.

POSITIONS WANTED—JUNE—W-203-25, 252-29, 263-31. AUGUST—W-312-40. SEPTEMBER—W-351-41. OCTOBER—W-383-43, 391-44, 398-45, 388-46, 375-47, 420-48. NOVEMBER—W-412-49, 428-50, 429-51, 445-52, 450-53, 449-55.

NEW POSITIONS OPEN

PRODUCT TEST ENGINEERS (four openings) for advanced field test work with an established broad line manufacturer in the Midwest. Age 30-50. BS deg in agricultural or mechanical engineering desirable. Farm background essential, plus six to ten years in the farm equipment field. Some tractor or implement design experience is desirable. Must have mature, sound judgment regarding the function and performance of farm equipment and be able to supervise and train younger, less experienced men. Opportunity for some travel throughout the United States and for advancement in an expanding organization. Salary commensurate to the background and experience of the applicant. O-401-761

INSTRUCTOR to teach refrigeration laboratory, air conditioning laboratory, electric motors and controls, and design of air conditioning, heating and ventilating systems, in eastern state technical institute. BS deg in engineering. Industrial and/or teaching experience 3 to 5 yr. Usual qualifications for success in engineering teaching. Normal opportunity for advancement. Increment salary increases. Opening effective immediately. Salary $5226 to start. O-476-786

AGRICULTURAL ENGINEERS (two project and one junior grade) for design and development of hydraulic devices and actuating circuits for use on agricultural equipment, with leading manufacturer of broad line of components. Midwest location. BS deg in engineering, or equivalent in experience. Experience with operation and design of hydraulic equipment desirable. Also general knowledge of control requirements of agricultural implements. Neat appearance. Ability to think on feet. Personality to permit customer contact. Excellent opportunity in progressive organization with executive personnel drawn largely from engineering staff. Salary open. O-503-787

AGRICULTURAL ENGINEER, 25 or over, sales minded, to implement electric load building program as rural representative for 85,000-meter midwest utility company. Located in North Central Iowa community of 30,000, maintain contacts with approximately 2,400 rural customers in surrounding area. Must be capable of assisting farmers in solving work problems with the application of electricity. Work also involves contact with equipment manufacturers, dealers, farm organizations and schools. Salary and car allowance. O-504-788

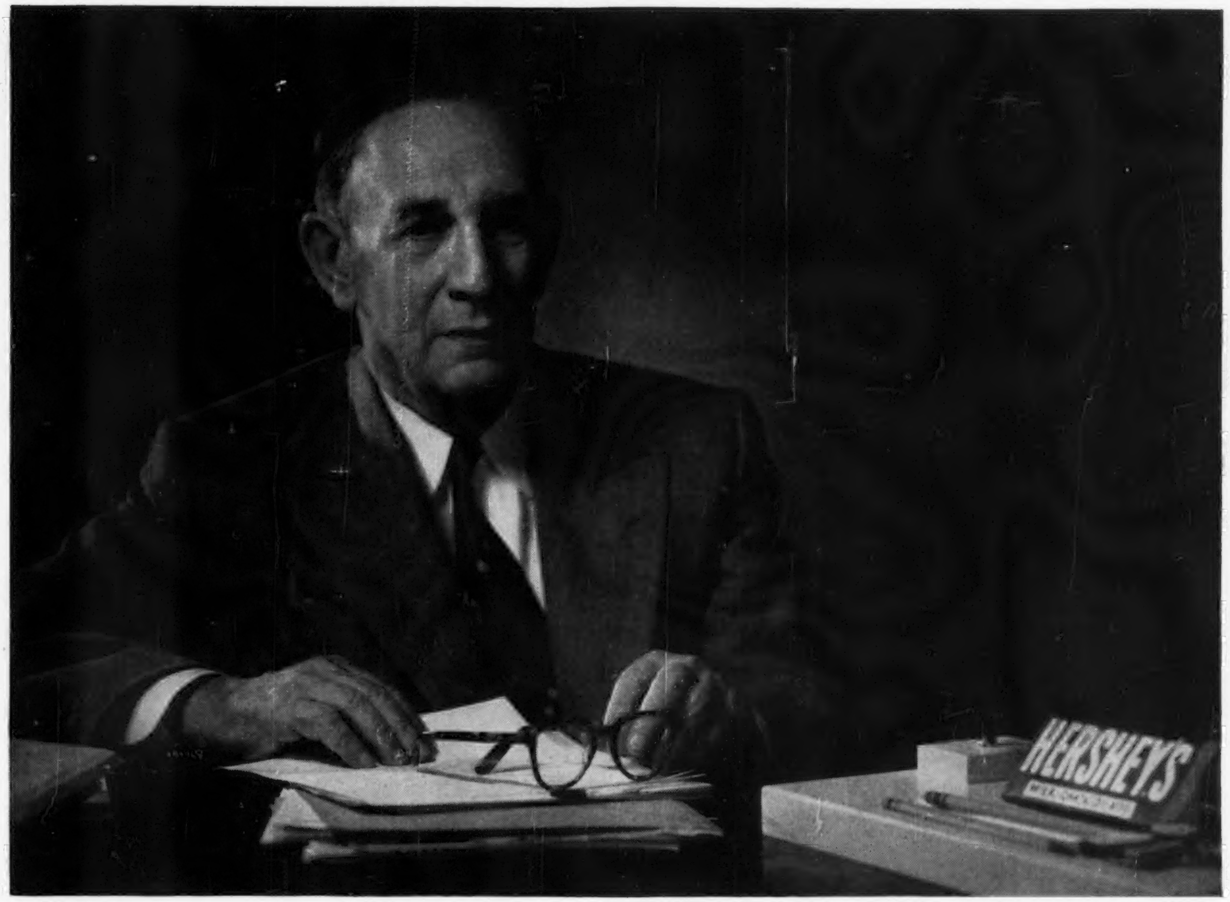
NEW POSITIONS WANTED

AGRICULTURAL ENGINEER for design, development or extension work in federal agency, in soil and water or civil engineering field in Western USA. Married. Age 55. No disability. BS deg in civil engineering, 1924, Oregon State College. Experience as civil engineer with electric utility, private railroad, county, and Forest Service. Past 20 years with Soil Conservation in capacities from camp superintendent to engineering specialist. Available on reasonable notice. Salary $8270 and expenses. W-458-56

AGRICULTURAL ENGINEER for extension, sales, service, or writing in rural electric or soil and water field, with private enterprise or public agency, anywhere in USA, or elsewhere where wife can accompany. Married. Age 30. No disability. BS deg in agricultural engineering, 1951, Ohio State University. Farm background. Agricultural engineer with electric utility one year. Short period with Ohio Department of Natural Resources on sedimentation surveys. Part-time work while in college on drainage of agricultural engineering department research farm. War enlisted service nearly 2 yr, Navy, electrician 3/c. Farm manager 3 yr. Available January 1, Salary open. W-486-57

AGRICULTURAL ENGINEER for design, development research or service in power and machinery or farm structures with private enterprise or state agency in Midwest, Southeast or foreign country. Married. Age 41. No disability. BS deg in agricultural engineering, 1939, Iowa State College. Experience as supervisor of work projects, National Youth Administration; varied engineering and related work in conscientious objector camps; free lance art work; work with National Cooperatives; headed 6-man unit for relief work in Ethiopia; building, selling and installing combination windows. Available on reasonable notice. Salary $5000. W-489-58

NEW GRADUATE for extension, teaching, research, sales, or service in power and machinery or soil and water field, with private enterprise or public service. Prefer South but will consider other locations. Married. Age 27. No disability. BS deg in agriculture expected January 28, University of Florida. Experience as farm hand 2 summers; in farm equipment shop 6 mo; as carpenter 6 mo, U.S. Navy 5½ yr, 1946-51, enlisted, 3rd/class petty officer, fire control man. Available in February. Salary open. W-480-59



P. A. STAPLES

Portrait by Fabian Bachrach

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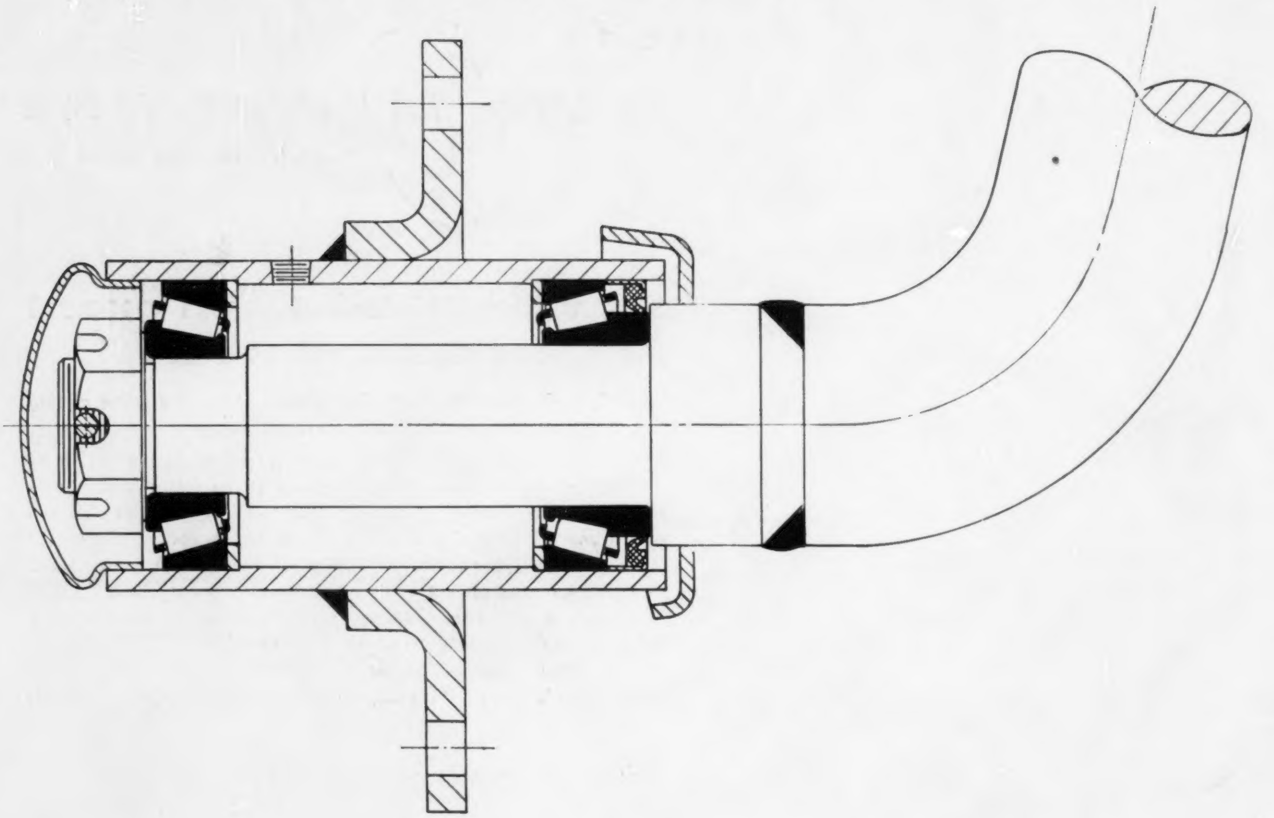

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